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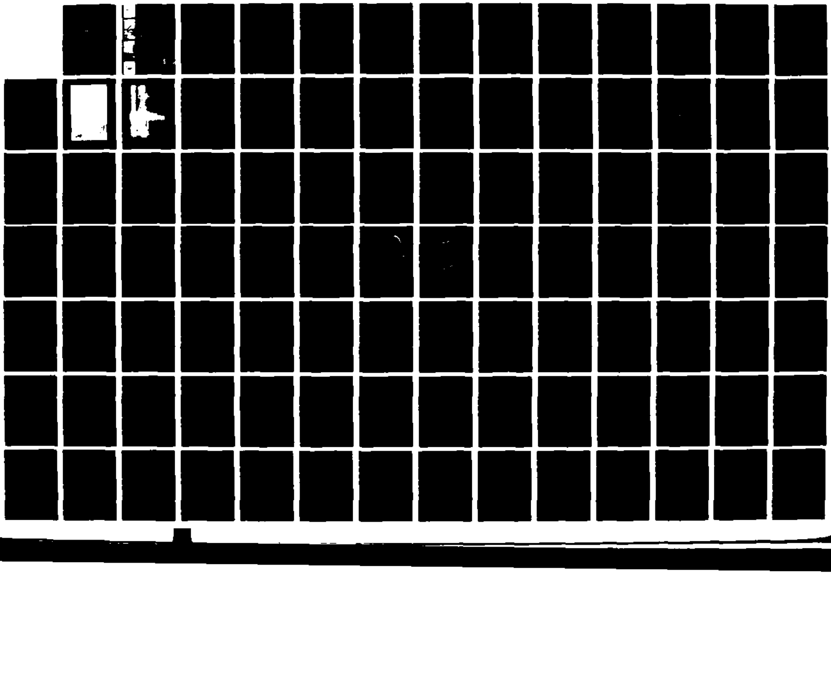

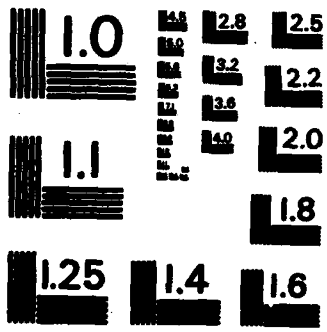

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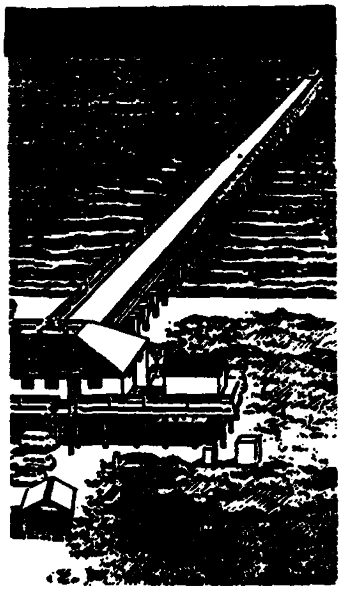

COASTAL ENGINEERING RESEARCH CENTER

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MISCELLANEOUS PAPER CERC-85-8

LOS ANGELES AND LONG BEACH HARBORS MODEL STUDY

DEEP-DRAFT DRY BULK EXPORT TERMINAL, ALTERNATIVE NO. 6: RESONANT RESPONSE AND TIDAL CIRCULATION STUDIES

by

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Studies to determine the effect of the proposed Deep-Draft Dry Bulk Export Terminal, Alternative No. 6, on tidal circulation and harbor resonance in Los Angeles and Long Beach Harbors were conducted. The plan included a total of 448 acres of landfill in Los Angeles Harbor and dredging a navigation channel and maneuvering area.

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20. ABSTRACT (Continued).

The effect of the proposed plan on tidal circulation was studied using an implicit-finite difference scheme numerical model with a two-dimensional depth-averaged formulation of the hydrodynamic equations. Tidal circulation was simulated for 70-hr sequences of spring, mean, and neap tides for existing and proposed plan conditions. Tidal elevations, velocities, discharges, flow volumes, net flow volumes, and dye concentrations were examined throughout the harbors. The plan produced no changes in tidal elevation or phase throughout the harbors. Only very slight changes occurred in flow distribution through the three main entrances to the harbors. Net easterly circulation in the outer harbor was reduced 21 to 24 percent. Net circulation in the inner harbor (Main Channel and Cerritos Channel) was reversed from the existing westerly flow to a net easterly flow of greater magnitude than for existing conditions, providing improved flushing of the inner harbor. Dye tests indicated no change in concentration in the shallow-water habitat for the plan when compared with existing conditions.

Harbor resonance for the plan was examined with a 1:400 horizontal, 1:100 vertical scale model of Los Angeles and Long Beach Harbors, and the results were compared with resonant response for existing conditions. Wave periods ranging from 15 to 400 sec were tested. The study produced results showing wave height amplification factors at 46 locations throughout the harbors. Testing indicated that for the proposed terminal locations along the island landfill and on Terminal Island the resonant peaks were relatively low. The 185-sec period wave produced the greatest wave height amplification of 5.1, but only at one location along Terminal Island. A 330-sec wave produced the only significant wave amplification (5.4) on the outer (or south) face of the island landfill. No significant resonant peaks were created at other locations throughout the harbors due to the plan except for a few very long periods (320 sec) at only a few locations. Some of the larger resonant peaks for existing conditions were reduced.

PREFACE

Authorization for the US Army Engineer Waterways Experiment Station (WES) to conduct physical and numerical model investigations of the Los Angeles Harbor Deep-Draft Harbor Plan, Alternative No. 6, was received from the US Army Engineer District, Los Angeles (SPL), on 17 April 1984.

The study was conducted during the period May-October 1984 by personnel of the Wave Dynamics Division (WDD), Coastal Engineering Research Center (CERC), under the general supervision of Drs. R. W. Whalin and L. E. Link, Chief and Assistant Chief, respectively, and the direction of Mr. C. E. Chatham, Chief, WDD, and Mr. D. G. Outlaw, Chief, Wave Processes Branch. Physical model tests were conducted by Messrs. L. A. Barnes, Civil Engineering Technician, and L. L. Friar, Electronics Technician, under the supervision of Mr. W. C. Seabergh, Project Engineer. Mr. K. A. Turner, Computer Specialist and Ms. M. L. Hampton, Computer Technician, aided in the development of plots of model data. Numerical simulations were performed by Mr. Seabergh with the aid of Ms. L. J. Thomas, Mathematician.

Project management for SPL was administered by Mr. D. Muslin under the general direction of Mr. D. G. Spencer, Chief, Coastal Resources Branch. COL P. C. Taylor, CE, was the District Engineer of SPL during the course of this study. General project administration for the US Army Engineer Division, South Pacific, was provided by Messrs. A. E. Wanket, J. R. Edminsten, and H. Converse.

COL Tilford C. Creel, CE, and COL Robert C. Lee, CE, were Commanders and Directors of WES during the conduct of the study; Mr. Fred R. Brown was Technical Director. COL Allen F. Grum, USA, was Director of WES at the time of publication of this report, and Dr. Robert W. Whalin was Technical Director.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
acres	4046.856	square metres
cubic feet	0.02831685	cubic metres
cubic feet per second	0.02831685	cubic metres per second
feet	0.3048	metres
feet per second	0.3048	metres per second
gallons (US liquid)	0.003785412	cubic metres
miles (US statute)	1.60934	kilometres
square miles (US statute)	2.589998	square kilometres
square feet	0.09290304	square metres

LOS ANGELES AND LONG BEACH HARBORS MODEL STUDY

DEEP-DRAFT DRY BULK EXPORT TERMINAL, ALTERNATIVE NO. 6: RESONANT RESPONSE AND TIDAL CIRCULATION STUDIES

PART I: INTRODUCTION

Objective

1. The Ports of Los Angeles and Long Beach have shown continual patterns of growth in commerce which require the planning for additional harbor basins, ship-mooring facilities, and the dredging of deeper channels to accommodate this expansion. To achieve a successful plan for harbor growth it is necessary to investigate, among other factors, the effect a plan will have on tidal flushing of the harbor area and on harbor resonance, where long-period harbor oscillations are important with regard to moored-ship movement. The purpose of the study described in this report concerns the investigation of a plan for a deep-draft dry bulk terminal. Both tidal circulation and harbor resonance were studied for a variety of test conditions.

Background

2. Los Angeles and Long Beach Harbors are located adjacent to each other and share a common breakwater system that encloses one of the largest harbor systems in the world. Their location on San Pedro Bay along the southern coast of California is shown in Figure 1. The various channels and basins are shown in Figure 2. In order to accommodate increased shipping activites, extensive expansion of facilities is anticipated; as a result, careful and comprehensive planning is required. As a part of the planning and design process, the Port of Los Angeles, the Port of Long Beach, and the US Army Corps of Engineers are evaluating the effects of expansion on tidal circulation and harbor resonance.

3. A physical model of Los Angeles and Long Beach Harbors was constructed at the US Army Engineer Waterways Experiment Station (WES) to investigate tidal circulation and wave-induced oscillations in the harbors for present conditions and for proposed plans; McAnally (1975) reported on tidal

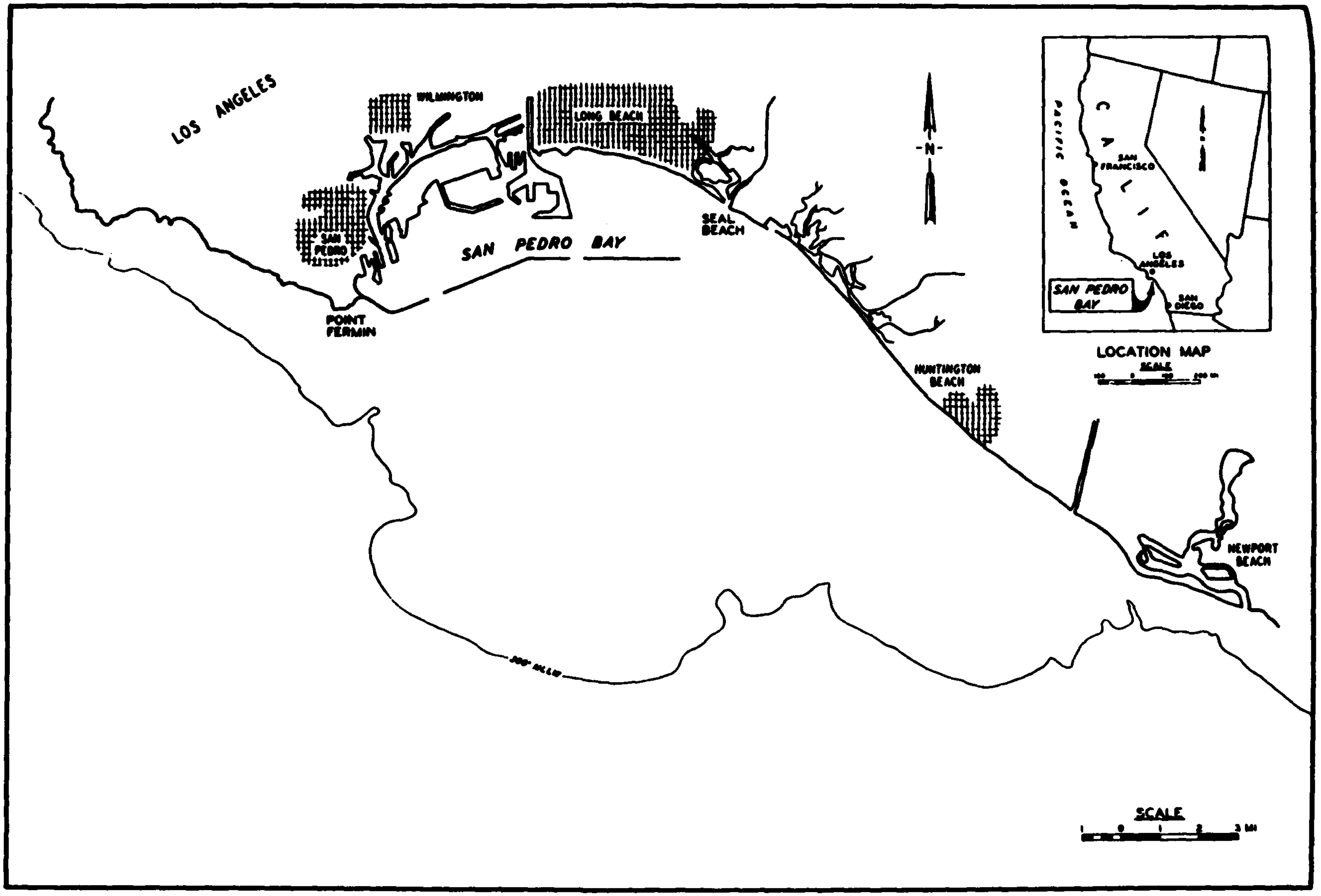

Figure 1. Site map: Location of the Los Angeles and Long Beach Harbors along southeast coast of San Pedro Bay

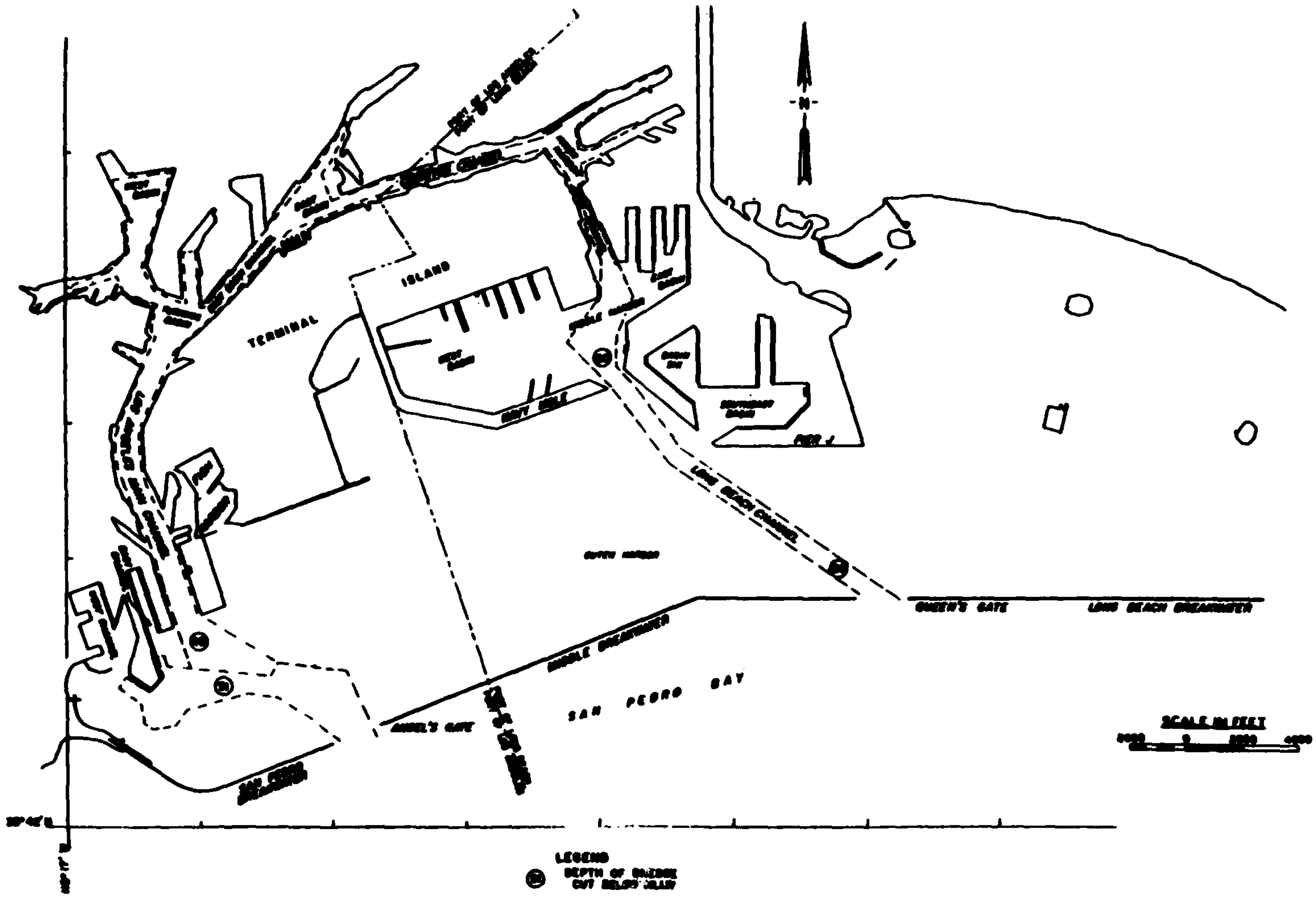

Figure 2. Location of city boundary and various channels and basins in the Los Angeles and Long Beach Harbors

verification and Outlaw et al. (1977) reported on model design. Numerical models also have been used for tidal circulation studies when necessary (Raney 1976a,b; Outlaw and Raney 1979; Seabergh and Outlaw 1984); these numerical studies were conducted during periods in which harbor resonance wave tests were being conducted in the physical model.

The Plan: Deep-Draft Dry Bulk Export Terminal, Alternative No. 6

4. Changes to the existing harbor for the proposed plan would consist of the following elements, which are shown in Figure 3:

- a. A 68-ft-deep* (National Geodetic Vertical Datum, (NGVD), 1,200-ft-wide channel extending from the -68-ft NGVD contour oceanward of Angel's Gate, through Angel's Gate into the harbor, where it gradually widens to 1,400 ft.
- b. A 68-ft-deep maneuvering and docking area.
- c. A 328-acre landfill located between Terminal Island and the middle breakwater.
- d. A 120-acre landfill located at the Los Angeles Harbor seaplane basin.

Though not part of the landfill plan, the proposed improvement configuration for Fish Harbor, Plan 1L, was included in the Los Angeles Harbor area (see Plate 1). Also in the Long Beach Harbor area, a proposed 135-acre landfill at Pier A plus increased depths as shown in Plate 2 were included in the study with the other plan elements as described above. The Fish Harbor and Pier A proposed plans are included as part of the existing conditions for the tidal circulation study.

Approach

5. For the simultaneous study of both harbor resonance and tidal circulation, the existing Los Angeles-Long Beach physical model was used to study harbor resonance and a numerical model was used to study tidal circulation.

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* A table of factors for converting non-SI units of measure to SI (metric) units is presented on page 3.

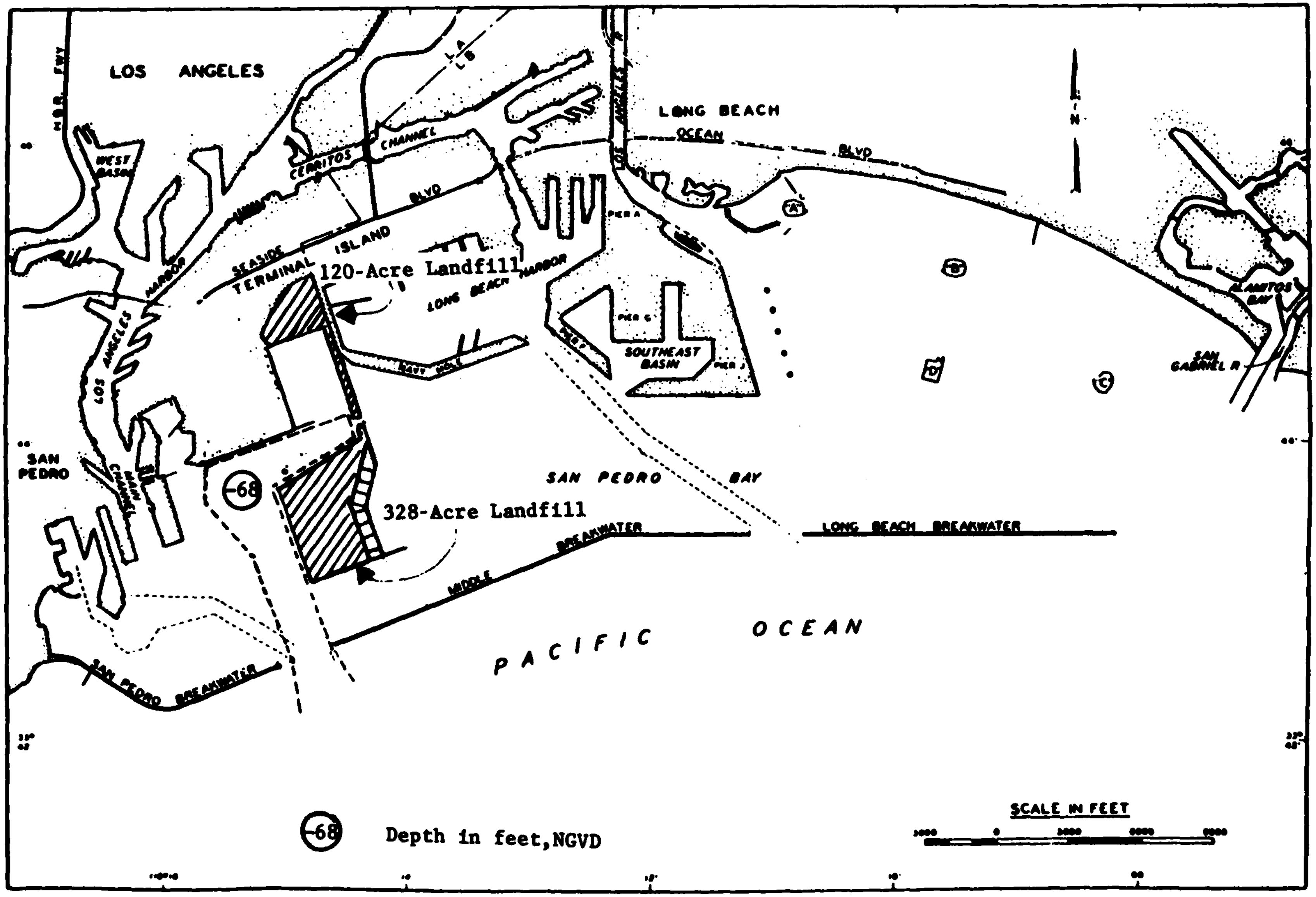

Figure 3. The plan

PART II: DESCRIPTION OF MODELS

Physical Model

6. The Los Angeles and Long Beach Harbors model was constructed to scale ratios, model to prototype, of 1:100 vertically and 1:400 horizontally. It was molded in concrete grout and reproduced San Pedro Bay and a portion of the Pacific Ocean surrounding the harbor, extending to an offshore depth of -300 ft. Total model area was approximately 44,000 sq ft, representing about 253 square miles in the prototype. A view of the harbor with the proposed plan is shown in Figure 4. The model is equipped with an electrohydraulic wave generator which has 14 units, each with a 15-ft wave paddle. The computer-controlled wave generator can reproduce waves with a prototype period ranging from 15 to 400 sec which have a variable wave height along a curved wave front. Wave data also are acquired by the same computer system from parallel wire resistance-type gages which can accurately detect changes in model water surface elevation* of 0.001 ft (0.1 ft, prototype). More information on model design, the wave generators, and the automated data acquisition and control system can be found in Outlaw, et al. (1977).

Numerical Model

7. The numerical model used in this study is known as the Waterways Experiment Station Implicit Flooding Model (WIFM). It provides a two-dimensional, depth-averaged, second order finite-difference solution to the hydrodynamic equations. Although the model has the capability to allow for flooding of low-lying terrain, this option was not required for the present study. A major advantage of WIFM is its ability to apply a smoothly varying grid to the study region, permitting simulation of complex shorelines or harbor boundaries. The grid used for this study is shown in Figure 5. The total grid was 128 cells wide by 94 cells long for a total of 12,032 cells. Minimum cell width was 235 ft and the maximum width was 1,463 ft. Total area covered by the grid was about 146 square miles.

8. The version of WIFM used in this study also includes a solution to

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* All elevations (el) cited herein are in feet referenced to NGVD.

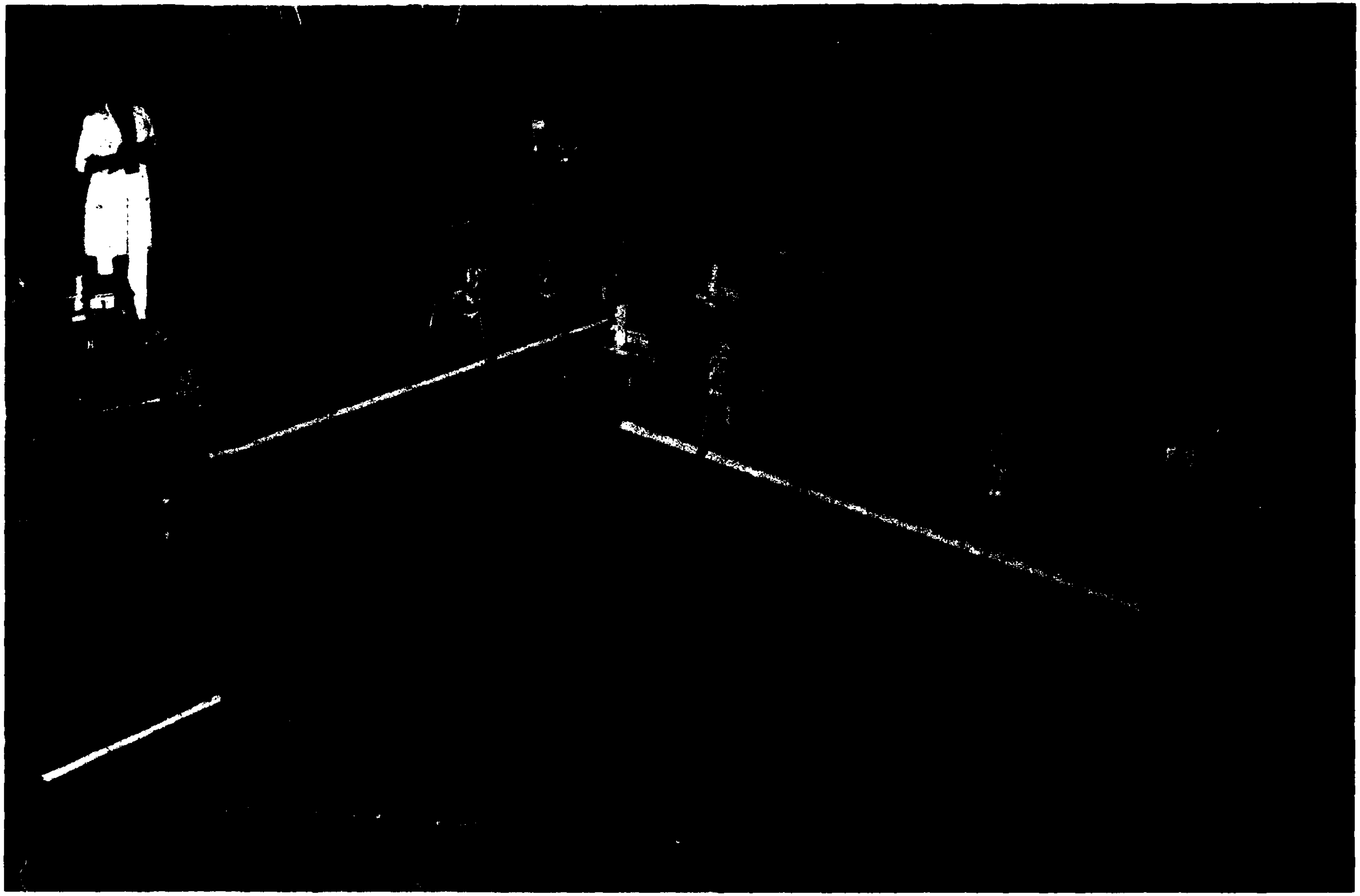

Figure 4. The model with the plan installed

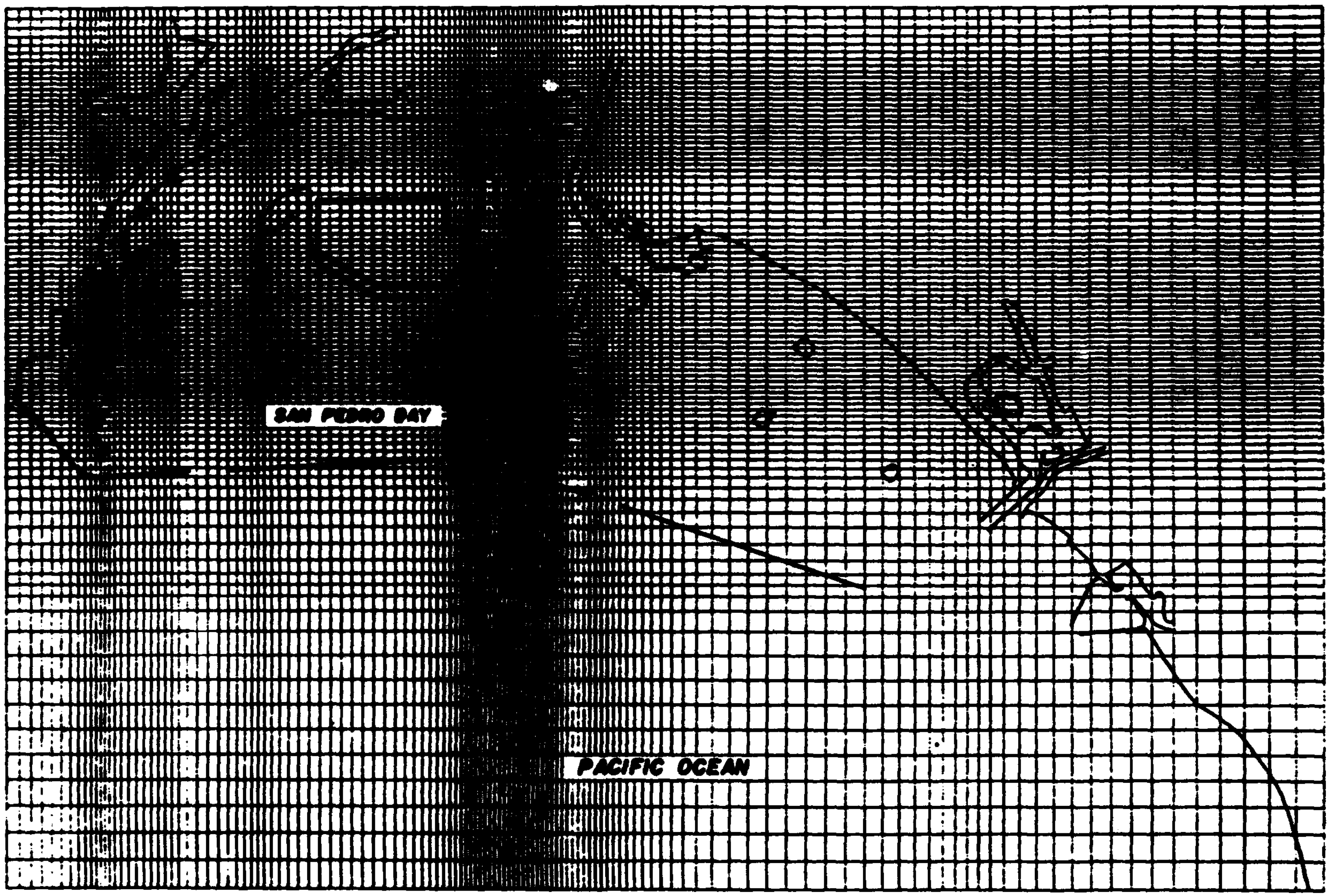

Figure 5. Grid layout over the harbor

the transport equation which permits the model to be used for the lateral dispersion of a conservative constituent. A more detailed discussion of the numerical model used appears in Seabergh and Outlaw (1984). For details of the model development the reader is referred to Butler (1978a,b,c, and 1980), and for the development of the solution to the transport equation, to Schmalz (1983).

PART III: RESULTS AND ANALYSIS OF THE TIDAL CIRCULATION STUDY

Application of Numerical Model to San Pedro Bay

9. The numerical model was used to examine existing conditions (as described in paragraph 4) and the proposed Deep-Draft Dry Bulk Terminal Plan, Alternative No. 6. For both existing conditions and the plan, three sets of tidal elevation input data were used. These sets of tidal elevation data were input along the model's ocean boundary to drive the model. The three sets of tidal input represented typical spring, neap, and mean tide conditions. These input tides were determined by a computer program which used 21 tidal elevation constituents, as determined by the National Ocean Survey. The spring tide, a tide of increased range (relative to the mean tide range) which occurs semimonthly as a result of the moon's being new or full, had a maximum range of 7.2 ft. The neap tide, a tide of decreased range (relative to the mean tide range) occurs semimonthly as a result of the moon's being in quadrature, had a maximum range of 3.5 ft. The mean tide used in the study had a maximum range of 5.5 ft.

10. The numerical model tidal circulation simulation for this study was run for 70 hr prototype time, with computations being performed for each 90-sec increment in time, or a total of 2,800 timesteps. At each timestep the numerical model calculates a water surface elevation, velocity components u and v in the x and y directions, respectively, and a concentration for each grid point (or computational cell) (Figure 5). Plots of these elevations or velocities versus time may be made for any selected cell location. A string of these cells may be used to compute a flow discharge through a given region, such as the entrance at Angel's Gate, by summing the product of the velocity commponent perpendicular to the channel cross section and the area through which the velocity flows for all the cells in the string. This produces an instantaneous discharge value with units of cubic feet per second. For this study, discharges are calculated every eight timesteps (or every 720 sec, prototype time). If a discharge value is multiplied by 720 sec, the volume of water moving through a certain cross-sectional area for the 720-sec time period may be computed, having units of cubic feet (cubic feet per second, seconds = cubic feet). These flow volumes can be summed over a given time period (usually over one, two, or four tidal cycles) adding flood flow volumes

and ebbflow volumes separately, with the difference between the two being a net flow volume. It is important to start and end the summary interval at the same water level so that there is no net storage on one side of the discharge and flow volume cross section. As mentioned above, spring, mean, and neap tidal conditions were run for both the existing and plan conditions, for a total of six simulation runs. Each simulation was of 70-hr duration, prototype time. At hour 18 of each simulation, the constituent transport calculations were initiated in order to simulate the sewage treatment plant outfall and these calculations were continued over the remainder of the test simulation. Velocity vectors also were computed and plotted for every second computational cell.

Preliminary Tests

11. Prior to testing the Deep-Draft Dry Bulk Export Terminal Plan, a follow-up study of the 2020 Plan testing (Seabergh and Outlaw 1984) involved the examination of flow between Terminal Island and the outer harbor landfill (Plate 3). A connection between the outer harbor landfill and Terminal Island was assumed to be supported on piles and spanned 1,200 ft for the 2020 Plan. In order to reduce the costs of such a structure, a short series of tests was conducted with the numerical model in which the 1,200-ft gap was narrowed to 800 then 400 ft. Depths at the structure would be 76 ft if this planned dredging were performed. If the region at the structures were not dredged, construction would be more cost effective due to shorter piles, so tests were made using the existing depths at the location of the proposed connecting structure also. Flow volumes were measured at the ranges shown in Plate 3. Tables 1 and 2 present east and west flow volumes at range 9A and net flow volumes for all ranges, respectively. Plate 4 shows a plot of the percent change in easterly flow volumes (as a percent of the flow volume for a 1,200-ft width by 76-ft depth cross section) versus the percent of the original 1,200- by 76-ft area. It can be noted from Plate 4 that for a 400-ft width by 28-ft depth (the existing depth) cross section, which is 12 percent of the original flow area, 42 percent of the original easterly flow volume is passing through. Table 1 indicates that the greatest portion of the flow is to the east for all cases tested. Table 2 indicates as net flow is reduced by decreasing the cross-sectional area at range 9A, net flow is decreased at

range 9B, indicating increased easterly flow at range 9B. Also net flow in Cerritos Channel (range 8B) is increased in the easterly direction as the cross-sectional area is reduced. This same trend is evident at ranges 5, 8, and 8A.

12. Based on these tests the minimum cross-sectional area of 400-ft wide by 28-ft deep was used in the Coal Terminal Plan since 42 percent of the net flow was maintained and a significant savings in construction could be obtained.

Tide Elevation and Phase for the Deep-Draft Bulk Terminal

13. Tide elevation data for existing conditions and the plan were collected for the tide gage locations shown in Plate 5. Plots of the hourly elevations are shown for the spring, mean, and neap test conditions in Plates 6-23 for gages 9, 10, 15, 16, 18, and 19. These gage locations are well distributed over the harbor area and all indicate no discernible change in tide amplitude or phase. Data for other tidal elevation stations shown in Plate 5, but not included in the report, also indicated no amplitude or phase change. These data are on file at WES. It can be noted that at gage 18 (Plates 18-20) adjacent to the shallow water habitat or at gage 15 near the Navy Mole, the proposed landfill had no effect on the tidal filling of these regions.

Tidal Velocities

14. Half-hourly tidal velocities are presented for both existing conditions and the Deep-Draft Bulk Terminal Plan over a 70-hr time period for the spring, mean, and neap tidal conditions in Plates 24-59. Locations of these velocity stations are shown in Plate 5. At velocity ranges where there are three stations across an entrance or interior channel, only the center station has been included in this report. Data for the stations adjacent to the center station are on file at WES. Table 3 presents the maximum flood flow and ebb flow velocities for each station and condition studied. This information will be discussed in the following paragraphs.

15. Velocities at station 1B (Plates 24-26) located at Angel's Gate showed a reduction during both ebb and flood flow. For example, peak flood

and ebb velocities of 0.76 and 0.98 ft/sec for the existing spring tide condition were reduced to 0.55 and 0.81, respectively, for the plan. The same trends were observed for the mean and neap tide conditions. These reductions can be attributed to: (a) an increase in cross-sectional area at the range 1 location, with depths increased from -54 ft NGVD to -68 ft NGVD; and (b) a slight decrease in tidal prism due to the replacement of tidal volume storage by the landfill.

16. Velocities at station 2E (Plates 27-29), the midchannel station at Queen's Gate, showed very slight changes in magnitude. Maximum flood velocities increased by 0.02 ft/sec for the plan over the existing conditions for spring tide (0.74 to 0.76 ft/sec) and mean tide (0.59 to 0.61 ft/sec) with no change of maximum for neap tide. Maximum ebb velocities decreased for the plan by 0.05 ft/sec for spring tide (0.63 to 0.58 ft/sec) to 0.02 ft/sec for mean tide (0.48 to 0.46 ft/sec) and 0.01 ft/sec for neap tide (0.34 to 0.33 ft/sec). The slight flood velocity increases were most likely due to the necessity for flood flow through Queen's Gate to fill a portion of the outer harbor which had previously been filled by flow through Angel's Gate (range 1). Ebb flow decreases reflect a slight reduction in net transport from Angel's Gate flows to Queen's Gate. An examination of flow volumes in a later part of the report will help explain these changes further.

17. Station 3H data (Plates 30-32) indicate very little change in velocities. Maximum flood velocities for spring, mean, and neap tides had the following respective changes between existing and plan conditions: 0.36 to 0.38 ft/sec, 0.31 to 0.32 ft/sec, and no change (maximum velocities equal to 0.16 ft/sec). Therefore, there was a very slight increase in flood velocities entering the large open easterly portion of the harbor. Ebb velocities at station 3H were reduced very slightly, with maximums reduced from 0.46 to 0.44 ft/sec, 0.39 to 0.38 ft/sec, and no change for spring, mean, and neap tide conditions, respectively. The slight increase in flood velocities was likely the result of diversion of more of the flood flow from Queen's Gate toward the Long Beach side of the landfill in the outer harbor and less flow toward the open easterly portion of Long Beach with range 3 producing an increase to replace that lacking from range 2 (Queen's Gate). The slight decrease in ebb velocity is the result of the chain reaction decrease of flood flow at range 1, ebb flow at range 2 and then at range 3.

18. Velocities at range 5 are represented by those at station 5M

(Plates 33-35). Changes are very slight as are those at stations 8Y, 8A-P, and 8BS (Plates 36-44). The analyses of flow variations at these locations will be better illustrated by the examination of flow volumes through these ranges in a later section of this report.

19. Station 10B velocities (Plates 45-47) indicated ebb velocities (west to east flow) predominate at this location between the large open eastern harbor area and the main portion of the outer harbor. Velocities are very similar for existing and plan conditions and once again the flow volume calculations will be more indicative of net water tansport characteristics.

20. Four velocitiy stations (V1, V2, V3, and V4) were located in the outer harbor region, with three of them adjacent to the proposed landfill configuration. Station V1 (Plates 48-50), directly adjacent to the southern face of the landfill, indicated a strong ebb (westerly flow) of 0.75 ft/sec for the plan, the maximum for spring tide. Existing conditions were usually westerly flow, as part of the circulation gyre of the outer harbor, with a maximum velocity of 0.28 ft/sec (spring tide condition) in an easterly direction. Station V2 (Plates 51-53) located at the 400-ft gap between the landfill and its connection with the Navy Mole (Plate 5) indicated a more oscillatory variation in velocities for the plan than for existing conditions, though still almost completely unidirectional as for exising conditions. The existing condition circulation gyre in the outer harbor (illustrated later by velocity vector plots) provided a more continuous velocity in the easterly direction. Maximum spring tide velocities were 0.32 ft/sec for existing conditions and 0.45 ft/sec for the plan. Station V3 (located on the edge of the channel midway between Queen's Gate and the Navy Mole) indicated increases in velocity for the plan (Plates 54-56). However, due to the method used in evaluating flow direction, the velocities show large swings from ebb to flood flows, which are actually only a slight change in direction. Current vector plots shown later describe flow direction better for this open harbor location. Spring tide velocity maximums were 0.30 ft/sec for the existing condition and 0.47 ft/sec for the plan. Station V4, located on the west face of the landfill, shows velocity decreases for the plan condition when compared with existing conditions (Plates 57-59). Maximum spring tide flood velocities are reduced from 0.60 ft/sec to 0.25 ft/sec for this nearly unidirectional flow location.

Tidal Discharges

21. Hourly tidal discharges for ranges 1, 2, 3, 5, 8, 8A, 8B, 10, 11, 12, and 13 (see Plate 60 for locations) are shown in Plates 61-71. Only the spring tide discharges are presented for each range; mean and neap tide discharges are on file at WES. Maximum flood and ebb discharges for all tidal conditions and locations are presented in Table 4. Discharges at range 1 (Plate 61) show a decrease in the flood flow discharges into the harbor through Angel's Gate for the plan. Peak discharges (Table 4) drop from 103,056 cfs for the existing conditions to 92,361 cfs for the plan. Ebb flow peak discharge indicates only a slight reduction for the plan. Slight changes at ranges 2 and 3 balance the changes at range 1 after the decrease in flow due to the landfills considered. Ranges 2 and 3 have slightly increased flood discharges and decreased ebb discharges for the plan when compared with existing conditions. Changes in peak flows are seen in Table 4. Discharge changes are not visually discernible in plots for ranges 5, 8, 8A, and 8B (Plates 64-67), but trends can be noted in Table 4. For flood flow conditions a decrease at ranges 5, 8A, and 8B is balanced by an increase at range 8 (Plate 60 for locations). Ranges 5, 8A, and 8B are on one side of the nodal point, or location of null flow, in the back channel region while range 8 is on the other side. Therefore, conversely, for ebb flows there is a slight increase at ranges 5, 8A, and 8B balanced by a decrease at range 8 for the plan. As will be seen by net flow volume computations, this indicated a reversal of net flow in the back channel region of the harbors. Range 10 (Plate 68) shows minor changes and the manner in which flow is almost continually flowing eastward. The reduction for the plan is due to the diversion of some of the flood flow through Queen's Gate toward the area east of the primary landfill. Range 11 (Plate 69) shows the predominant eastward flow through the channel between the landfill and the connector with the Navy Mole. Range 12 (Plate 70), south of the major landfill area, has a reversing flow condition for the plan, while for existing conditions the flow through this location was continually westward as part of the circulation gyre in the outer harbor. Range 13 (Plate 71) shows the discharge flux across the outer harbor between the Navy Mole and the Middle Breakwater. For existing conditions the discharge through this relatively wide range shows a net flux almost continually eastward. With the plan installed there are some reversals in the discharges

since flood flow from Queen's Gate must now fill a portion of the outer harbor on the west side of the discharge range.

Tidal Flow Volumes

22. Total flood, ebb, and net flow volumes are shown in Tables 5 and 6 for each range (Plate 60 for range locations). Each flow volume is a one-tidal-cycle average (approximately a period of 12.5 hr) of four continuous spring, mean, or neap flood/ebb tidal cycles; the initial and final water surface elevations over the averaging period were the same, so there was no net storage. The analysis of the flow volume is very similar to that for the tidal discharges since the volumes are determined by the integration of the discharges over a time interval. Considering ranges 1, 2, and 3 in Table 5, these ranges control the flow into and out of the harbor. Flood flow (spring tide) volume changes between existing and plan conditions for ranges 1, 2, and 3 are -126, +9, and +27 ($\times 10^6$) cu ft, respectively. Therefore, the net decrease in flood flow volume is -90×10^6 cu ft, due to the displacement of tidal prism storage by the landfills (volume displaced between low water tide level and high water tide level). Range 1 is most significantly impacted, since for existing conditions water which filled the landfill region entered through range 1. Range 2 flood flow volume had increased in order to help fill the outer harbor on the east side of the landfill. Range 3 also increased since water filling the eastern outer harbor from range 2 was diverted more toward the landfill region and increases were required at range 3 to cover this shift in flow volume. Ebb flow volumes at ranges 1, 2, and 3 showed the decrease in harbor tidal prism due to landfills distributed as -20, -32, and -40 ($\times 10^6$ cu ft), respectively. Adding these values for ranges 1, 2, and 3, the net change in ebb tidal prism for the spring tide condition is -92×10^6 cu ft, very nearly equal to the change in flood flow tidal prism of -90×10^6 cu ft, as it should be. The same trends, but of lesser magnitude, were observed for mean and neap tides. Table 6 presents the net flows, that is, the difference between flood and ebb volumes for each range and each condition tested. Figure 6 shows these values for spring tide conditions, as well as the flow volume values themselves. Net flow volume declined for range 1, from +175 to +69 ($\times 10^6$ cu ft) (the flow became less flood-dominant for the plan than for existing conditions) while at range 2 the

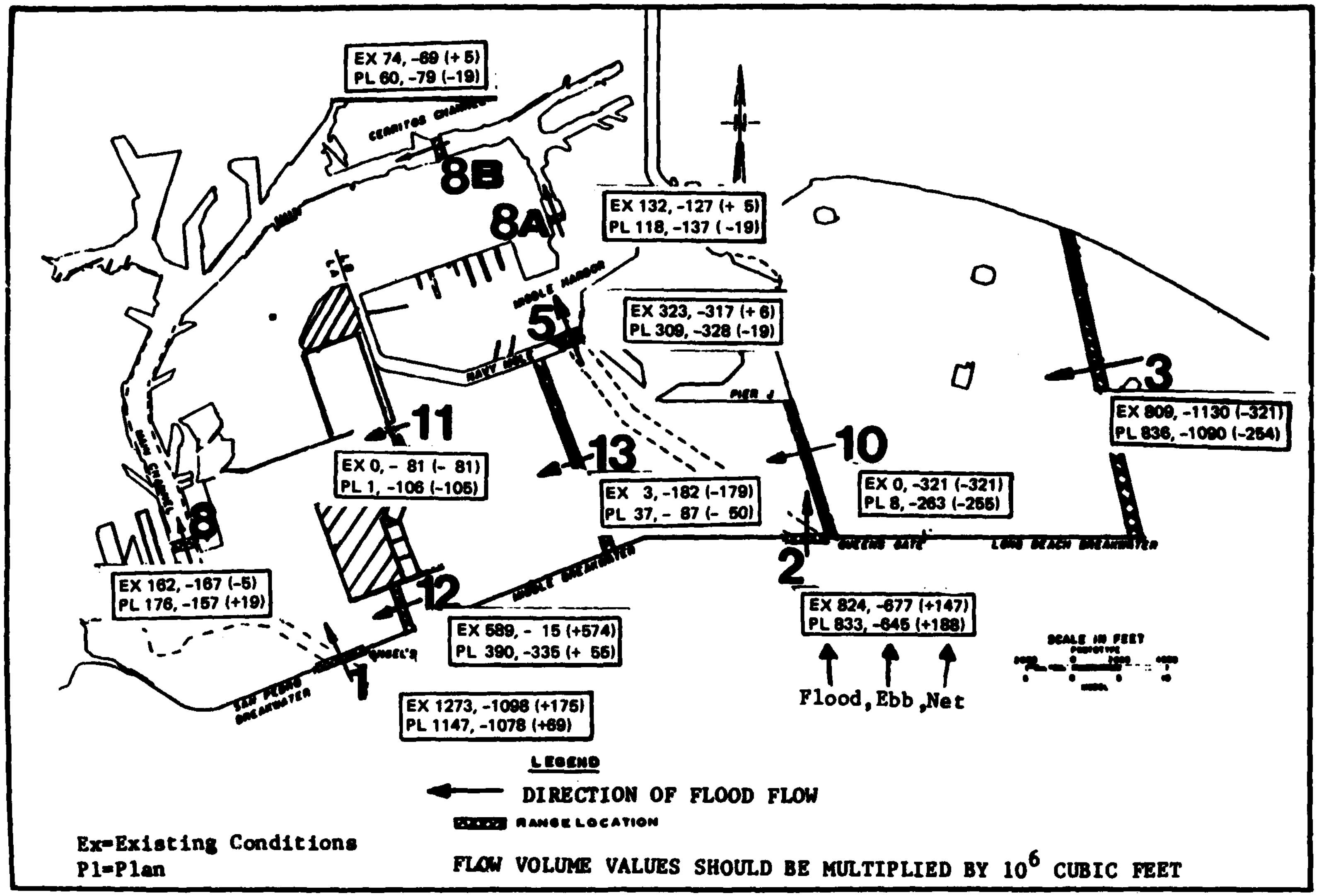

Figure 6. Flood, ebb, and net flow volumes for spring tide conditions

net flow increased from +147 to +188 ($\times 10^6$ cu ft). At range 3 the existing condition ebb-dominated flow of -321 ($\times 10^6$ cu ft) was reduced to -254 $\times 10^6$ cu ft for the plan. The tabulation below presents percentage of flow for each range for spring tide conditions:

	Distribution of Flow, percent			
	Flood Flow		Ebb Flow	
Range	Existing Condition	Plan	Existing Condition	Plan
1	43.8	40.7	37.8	38.3
2	28.4	29.6	23.3	22.9
3	27.8	29.7	38.9	38.8

The above tabulation shows the small shift of flood flow from range 1 to ranges 2 and 3. Range 1 indicated an increase of percentage of ebb flow with small drops at ranges 2 and 3.

23. Ranges 5, 8A, and 8B had changes between existing flow volumes and the plans which were identical, or nearly so, for flood and ebb flows (spring tide condition). Flood flow volumes decreased by -14×10^6 cu ft and ebb flow volumes increased $+10 \times 10^6$ cu ft. Therefore, the volume moving past a given range (5, 8A, or 8B) over a tidal cycle indicated a reduction of 4 $\times 10^6$ cu ft. However, taking range 8B spring tide conditions as an example, the net flow for this location increased from 5 to 19 $\times 10^6$ cu ft, and reversed direction (Figure 6). Therefore a particle of water would tend to move through the back channel region faster for the plan condition than for existing conditions. Also, the direction of this net movement would be reversed for the plan from that of the existing conditions. Ranges 5 and 8A indicated the same response to the plan as range 8B. Range 8 data in Los Angeles Harbor's Main Channel also followed the same trend, except the net flow value was reversed. Ebb flow had predominated for the existing condition and reversed to net flood flow for the plan (Figure 6). At range 8 the difference in existing and plan flood flow volumes for spring tide was +14 $\times 10^6$ cu ft and for ebb flow was -10×10^6 cu ft (Table 5). Therefore, the flow volume moving past range 8 increased 4×10^6 cu ft. Since total flow volume decreased at range 8B by -4×10^6 cu ft, the null velocity or nodal point location between ranges 8 and 8B shifted toward range 8B by the very small amount of 114 ft (4×10^6 cu ft divided by the average channel cross section, 35,000 sq ft).

24. Range 10 flow volume data indicated all flow was to the east for

existing spring tide conditions and nearly so for the plan (Figure 6). The easterly flow reduction for the plan results from flow diversion of the flood flow through Queen's Gate toward the new landfill region. This decrease of easterly flow is made up for by the increase in flood flow through range 3.

25. Range 11 flow volumes indicated that a net flow of 10×10^6 cu ft passed through the 400-ft-wide gap for the plan (spring tide condition) in an easterly direction. Return flow was only 1×10^6 cu ft for the plan. At range 12, flow volumes were primarily westward for the existing condition since this region was located in the southern part of a clockwise circulation gyre in the outer harbor. The plan created a reversing flow condition, with a net westerly flow of $+55 \times 10^6$ cu ft toward Angel's Gate. Range 13 indicated that there was reduction of net easterly flow across the outer harbor for the plan. Existing conditions produced a net flow of -79×10^6 cu ft while the plan had -50×10^6 cu ft for spring tide conditions. This also was true for mean and neap tides, although the change in net flows between existing and plan conditions was not as great for these two tide conditions as that of the spring tide (i.e. the lower tidal energy flows do not promote as large a west-to-east exchange of water across the outer harbor for existing conditions).

Tidal Circulation--Velocity Vector Plots

26. The previous sections' discussions concerning changes in flow volume are illustrated as well by examination of the velocity vector plots which show an instantaneous velocity condition over the study area. Plates 72-95 show these velocity vectors, which represent the velocity at every second cell location of the model grid. Four plots for each combination of tide and condition are presented. Velocities less than 0.01 ft/sec do not appear on the plots and blank regions indicate very low velocity values. Velocities within the 0.01-0.15 ft/sec range are difficult to determine because the vector length is within the triangular vector head and does not reproduce too well from the video plotter used in this study. Velocities greater than 0.15 ft/sec have the vector stem projecting down from the base of the vector head and can be scaled off easily. (Refer to Plate 60 for location of ranges.)

27. Plates 72-83 present the tidal circulation patterns for existing

conditions. Plates 72 and 73 show tidal circulation during ebb conditions of a 7-ft fall of the tide and Plates 74 and 75 show velocities during the following rise in spring tide level. The clockwise gyre in the outer harbor was noted as a dominant feature of the circulation developed by flood flow through range 1 (Plates 74 and 75). The gyre persists through ebb flow conditions (Plates 72 and 73) as flow strengthens along the breakwaters toward range 1. During the strength of flood flow for the existing spring tide condition, there was flow along the Navy Mole into range 5 (Plates 74 and 75) which entered the harbor from range 1. It can be noted that the flood flow through range 2 eddied south of Pier J and did not appear to significantly contribute much flow toward range 5 early in flood flow (Plate 74). However, in the later part of flood tide conditions, a clockwise rotational eddy brought some of the flow originating at Queen's Gate toward and into range 5.

28. Existing condition flood flow through range 1 (Plate 75), which moved northwesterly, split into two parts: (a) a counterclockwise eddy which returned toward the entrance, and (b) a flow which continued into the Main Channel (range 8). The flow nodal point in the back harbor region occurred in the East Basin Channel. It can be noted that the eddy strength decreased as the tide range decreased (i.e. for mean and neap tide conditions) and for neap conditions (Plates 80-83) only the main gyre in the central portion of the outer harbor was significant. Also flood flow through Queen's Gate more nearly followed the entrance channel toward range 5 at the Navy Mole (Plate 83) than for spring or mean tide conditions.

29. Effects of the plan on flow patterns, using spring tide conditions, can be made by comparing Plates 72-75 with 84-87, respectively. For ebb flow, comparing Plates 72 and 84, flow patterns at Angel's and Queen's Gates (ranges 1 and 2, respectively) are similar for existing and plan conditions. The counterclockwise eddy near the entrance to Main Channel (near range 8) has decreased, producing smaller crosscurrents at the entrance to that channel for the plan. The large central eddy gyre in the outer harbor has been eliminated for the plan as would be expected, although the circulation pattern of currents on the Long Beach side of the landfill retains some of the characteristics of the existing flow conditions in the outer harbor. These similar characteristics were eastern flow along the Navy Mole (reduced for the plan) and movement of some ebb flow from range 5 southward, then westward along the

breakwater toward range 1. The westward turn for the plan came about the midpoint of the outer harbor rather than at the breakwater. Flow patterns within the shallow water habitat were similar, with the flow existing this region turning westward and toward range 1 for the plan rather than becoming entrained in eastward flow for the existing conditions. The commentary for comparison of the ebb conditions in Plates 73 and 85 is similar to that just discussed.

30. Flood flow comparison of existing and plan spring tide conditions (compare Plates 74 and 86, and 75 and 87) illustrates the previous discussions of tidal volumes and net flows. Increased flow from range 1 toward range 8 and Main Channel can be noted for the plan (compare Plates 75 and 87) which helped create a change in net flow in the back harbor. A decrease in flood flow along the Navy Mole toward range 5 for the plan also was a factor in the reversal of net flow in the back harbor, although most of the loss in this flow was made up by an increase of flow from range 2, Queen's Gate, toward the range 5 region. Strong flood currents are noted along the south face of the outer harbor landfill in contrast to the slow eddy currents of existing conditions for this location. Flood flow currents into the shallow-water habitat were slightly increased with perhaps a stronger circulation being set up in this area for the plan, as a slight couterclockwise circulation is being set up which would permit better flushing of this area (compare Plates 75 and 87).

31. The commentary on ebb and flood spring tide conditions is generally applicable to the mean and neap tide conditions. Eddies are not as intense for these tidal conditions and flow lines are straighter and deviations between existing and plan conditions were not as striking or as easily observed.

Dye Movement

32. The injection of dye (representing a conservative substance) at a sewage outfall located as shown in Plate 5 was simulated for each condition studied. The grid block at which the dye was introduced was initially filled with dye of 100 ppt concentration, then an inflow of 24 million gallons per day of 100 ppt was continually run. Initiation of the dye study was at hour 18 of the numerical simulation and the inflow was maintained until the end of

the simulation (hour 70). Plates 96-119 show contours of the dye concentration as the dye dispersed through the harbor for each tide condition (spring, mean, and neap) for the existing and plan conditions. Four plates are shown for each combination of tide and study condition (one each for hours 31, 37, 62, and 68). In each case, the selected time is either at high water or low water of the tidal cycle.

33. Plates 96-107 present results for existing conditions. Hour 31, spring tide condition, 13 hr after the initiation of dye release (Plate 96), shows the influence of the outer harbor circulation eddy. Dye was carried east, along the Navy Mole, and south, back toward Angel's Gate. Hour 37, just after an ebb flow, shows the dye move toward Angel's Gate (Plate 97). By hour 62 (Plate 98) the dye had largely dispersed, generally toward the eastern half of the outer harbor with low concentration of between 0.1 and 1.0 ppt. Also noted was the movement of low concentrations of dye into Long Beach Middle Harbor (i.e. through range 5) and into the shallow-water habitat adjacent and west of the Navy Mole. The mean tide dye test (Plates 100-103) was somewhat similar to that of the spring tide test. The neap tide existing condition test maintained higher concentrations and movement was limited to the outer harbor circulation gyre with a slow drift along the Navy Mole since velocity conditions are much reduced for the neap tide condition. For each tide condition for the existing conditions, the initial movement from the sewage outfall region was eastward. There was no movement toward Fish Harbor.

34. Plates 108-119 show the results of the dye tests with the plan in place for the same tidal and dye conditions as were simulated for existing conditions. The one computational cell located at the sewage outfall was initially dyed with the same concentration (100 ppt) as for existing conditions. Since the depths due to dredging for the plan were about twice that for existing conditions, there was about two times the initial mass of dye for the plan tests. The flow input rate of dye was the same for existing and plan conditions.

35. Plates 108-111 show results of the plan test with the spring tide. Movement of the dye is slower. Hour 31 (Plate 108), just after flood flow, shows movement through the gap between the outer harbor landfill and the connecting landfill. Hour 37 (Plate 109), after ebb flow, shows that dye also exits the outfall region southwesterly towards Angel's Gate. Much later, (hour 62, Plate 110) there is significant dye movement through the gap and

along the Navy Mole, with the plume turning southward near the entrance to Long Beach's middle harbor. By this time the existing condition had significant influx into middle harbor (compare with Plate 98). To the west of the dye input location there was movement to the jetty of Fish Harbor (the jetty is not in place in the prototype, but is part of Plan 1L). Movement into the shallow-water habitat of Los Angeles Harbor is similar for existing and plan conditions. Six hours later, after a flood flow (Plate 111), conditions in the shallow-water habitat are still somewhat similar for existing and plan conditions (compare Plates 99 and 111). Averaging the values of concentration in the shallow-water habitat at hour 68, the existing conditions had an average concentration of 0.112 ppt, while for the plan, the average concentration was 0.108 ppt. Concentrations of dye remain higher in the vicinity of the outfall for the plan due to slower velocities in the region, but there is good movement both east and west out of the outfall region.

36. Mean tide testing of the plan produced similar trends of dye movement as the spring tide plan tests. Comparison of existing (Plate 103) and plan (Plate 115) conditions at hour 68 indicated about the same patterns of concentration in the shallow-water habitat region and no inflow of dye into Long Beach's middle harbor for the plan. Neap tide testing of the plan (Plates 116-119) showed the same trend of movement as the spring and mean tide, but at a much slower rate. There is no movement of dye into the shallow-water habitat for the plan but there were low concentrations for existing conditions (compare Plates 107 and 119).

PART IV: HARBOR OSCILLATION TESTS AND RESULTS

Testing and Data Analysis Procedures

37. Harbor oscillation wave tests were conducted for the Deep-Draft Dry Bulk Terminal, Alternative No. 6, and were compared with results from existing conditions (as discussed in Outlaw 1979). Wave gages were located as shown in Plate 120. Due to placement of gages in and near areas of proposed improvements, not all wave gage locations seen in Plate 120 have corresponding existing condition data for direct comparison (22 of 46 gages are in corresponding locations). One hundred and eighty data collection runs were made covering prototype wave periods from 15 to 400 sec. The wave period interval between tests varied from 0.5 to 2.5 sec (prototype). Smaller period increments between wave tests were used in the lower period range to ensure accurate definition of sharp resonant peaks. For each run, data were collected at 46 gages. The significant wave height at each gage location was calculated from the digital wave record (24-60 recorded cycles). The still water level used during model testing was 0.0 ft NGVD.

38. The plots presented in Plates 121-166 are those of wave-height amplification versus period. Wave-height amplification is traditionally defined as the ratio of the wave height at a particular location in a harbor to twice the incident wave height at the harbor mouth. The definition results from the fact that the standing wave height for a straight coast with no harbor is twice the incident wave height, due to superposition of the incident and reflected waves. In the model, the wave heights also are affected by refraction and are variable along the outer harbor breakwater. These wave heights are significantly different at Queen's Gate and Angel's Gate and are even variable along the model wave generator. Therefore, another definition of amplification is necessary. A consistent definition can be based on the incident wave height in deep water seaward of the model wave generator location. Therefore wave-height amplification, R , for the model was calculated as the ratio of the significant wave height, H_s , at each gage location to the incident wave height, H_i , which would have occurred at the initial wave-front position (approximately 38 miles seaward of the breakwater) used in the model design wave refraction analysis or:

$$R = \frac{H_s}{H_i}$$

Care must be taken when examining the wave data plates of amplification versus period due to the various amplification scales used on the ordinate axis. Also, there is a variation in increments of period along the abscissa axis, with the change occurring at 120 sec.

Discussion of Test Results

East Channel

39. Gage 2, located at the end of East Channel (Plate 122) indicated significant reductions for the Deep-Draft Terminal Plan at two lower peak periods of 60 and 96 sec when compared with the base. From 120 sec up to 280 sec, wave-height amplifications between base and plan were similar with slight shifts in peaks. The largest shift occurred for the peak amplification of the plan condition at 340 sec. The base condition had a peak at 385 sec. Gage 3 (Plate 123) showed a response similar to that of gage 2 when comparing plan with base conditions. Gage 4, at the coal terminal in East Channel, indicated a large decrease of wave-height aplification at 96 sec, otherwise small variations up to 290 sec, and relatively small increases for the plan between 290 and 330 sec.

West Channel

40. Gages 5-11 (Plates 125-131) cover the West Channel and vicinity. Gage 10 (Plate 130) is the only location which has a base data comparison. The plan generally has a reduction in wave-height amplification to about 300 sec when compared with base data at gage 10. Resonant peaks for the plan occurred at 60, 250, 340, and 400+ sec, though amplification factors were less than two for all but the largest period. Gage 5 (Plate 125), just outside the West Channel, indicates no significant amplifications at this westernmost location in the outer harbor. Gage 6 (Plate 126), at the entrance to West Channel, has resonant peaks at 70 sec (amp = 2.8), 105 sec (amp = 1.5), 165 sec (amp = 1.2), 285 sec (amp = 2.5), 340 sec (amp = 1.5), and 400 sec (amp = 2.8). Gage 7 (Plate 127) in the corner of the relatively new West Channel boat basin indicated resonant periods of 61 sec (amp = 2.3), 165 sec (amp = 4.6), 245 sec (amp = 2.0), 285 sec (amp = 2.5), and 340 sec

(amp = 5.2). Gage 8 (Plate 128) indicated no troublesome areas, while gage 9 had resonant peaks at 245 sec (amp = 2.7), 345 sec (amp = 2.4), and 400+ sec (amp = 3.6+). Gage 11 (Plate 131) had resonant peaks with wave-height amplification slightly greater than 2.0 for 105, 112, 165, and 245 sec. At 340 sec the amplification was 3.3.

Fish Harbor

41. Gages 12-17 (Plates 132-137) were located in Fish Harbor, which had Plan 1L in place. The 155-sec resonant amplifications ranged from about 4 to 6 at each gage. Other periods of resonant peaks present at the Fish Harbor gages were 76 sec (amplification range, <1.0 to 3.8), 92 sec (<1.0 to 2.2), 185 sec (<1.0 to 2.2), and the span between 220-265 sec (1 to 4).

Main Channel and Los Angeles West Basin

42. Gage 18, in the Los Angeles Harbor Main Channel (Plate 138), showed slight increases for the plan over base data above 135 sec, but wave-height amplification was just over 1.0 for periods of 160, 190, 210, and 295 sec. Maximum amplification was 2.9 at 395 sec for the plan, with the base having an amplification of 2.1. Gage 19 (Plate 139) in the Los Angeles Harbor West Basin showed no significant change.

Long Beach West Basin

43. Gage 20 (Plate 140) in the northwest corner of Long Beach Harbor's West Basin indicated that the plan had significant reductions of wave height amplitude when compared with the base condition for 46-, 60-, and 80-sec periods. Some increases were noted at 96, 195, 265, and periods over 320 sec.

Shallow-water habitat

44. Gage 21 (Plate 141), located in the northeast corner of Los Angeles Harbor's shallow-water habitat, had resonant peaks of amplification between 2 and 4 for periods of 185, 200, 250, 265, 295, and 355 sec.

Deep-Draft Terminal

45. Gages 22-32 (Plates 142-152) were located in the vicinity of the proposed Deep-Draft Dry Bulk Export Terminal. Gages 22-28 were in the somewhat confined region between the large landfill island and the southwestern portion of Terminal Island. The sharpest and largest resonant peak of wave-height amplification in this area was for the 185-sec period. A maximum wave-height amplification of 5.1 occurred at gage 23. Other periods with relatively smaller resonant peaks in the gages 22-28 region were 65 sec (wave-height amp = 1.9 at gage 27), 67 sec (amp = 1.6 at gages 22 and 27), 100 sec (amp = 1.8

at gage 25), 200 sec (amp = 2.0 at gage 22), 295 sec (amp = 3.5 at gage 25), 330 sec (amp = 2.0 at gage 25), and 340 sec (amp = 2.0 at gage 25).

46. Gages 29 and 30 were located on the west face of the Island landfill. There were no significant peaks at gage 29 and no peaks with wave-height amplification greater that 2.1 (225-sec period) at gage 30.

47. Gages 31 and 32 (Plates 151 and 152) indicated a slightly higher average energy level than the other deep-draft terminal gages, but the only large resonant peak was at 330 sec with a wave-height amplification of 5.4. There were numerous periods with peaks near wave-height amplifications of 2.

48. Contour plots of wave-height amplification for periods of 100, 185, 200, and 265 sec are presented in Plates 167-170 for the deep-draft terminal. These contour plots of wave-height amplification are made from wave height measurement of a closely spaced array of wave gages. The plots depict the nodes (minimum values of vertical amplification) and antinodes (maximum values of vertical amplification) of the resonant oscillation. Maximum currents and the maximum horizontal water displacement occur near the nodal area of the oscillation and cause the most significant ship-mooring problems. Overall, where nodal areas occur in the proposed mooring areas, adjacent amplifications are usually small, indicating relatively small currents. For the 185-sec wave condition (Plate 168) there are high amplifications on the south edge of Terminal Island, but nodal points occur outside the mooring area.

Southeast Basin

49. Gages 34-39 (Plates 154-159) are located in the Southeast Basin. These gages indicated some variations between the base condition and the plan. The greatest changes were reductions in wave-height amplification for the plan at gage 37 for 230 sec (Plate 157, amplification reduced from 9 to 4) and at gage 39 for 78 sec (Plate 159, amplification reduced from 4.9 to 2.8). Increases for the plan were noted for 54, 200, and 340 sec at gage 34, with general slight increases at the longer periods above 300 sec. Gage 35 (Plate 155) showed some small reduction for the plan in wave-height amplification up to about 295 sec, then slight increases of low amplification above 295 sec. Gage 36 (Plate 156) had slight increases in wave amplification at 49 sec (amp = 1.9), 102 sec (amp = 3.0), and 205 sec (amp = 3.6) with decreases at 79 sec. Gage 37 (Plate 157) indicated that other than the large decrease at 230 sec, there were only two small jumps of wave amplification at 41 and 101 sec. Gage 38 (Plate 158) indicated reduction in wave amplification

for the plan and slight shifts in period at 93 and 98 sec. Slight increases at gage 38 occurred for 180, 250, 268, and 302 sec, although all amplifications were about 2.0 or less. Gage 39 (Plate 159) had the largest reduction at 78 sec and slight increases at 160, 205, 250, and 265 sec.

Back channel and East Basin

50. Gages 40 and 41 (Plates 160 and 161) located in the back channels, usually had a reduction in wave-height amplification for values greater than 2.0. Reductions for the plan (at gage 40) were apparent on the 200- to 220-sec region and some increases were noted for periods greater than 320 sec. Gage 41 indicated an increase at 200 and 220 sec, but the wave amplifications were 2.0 and less.

51. Gages 42-44 (Plates 162-164) had reductions in the 75- to 85-sec range at all three locations for the plan. Increases for periods over 320 sec were observed.

52. Gages 45 and 46 are located in Queensway Bay at the entrance to the flood control channel. Gage 45, adjacent to the Queen Mary, had some new resonant peaks at 104 and 174 sec plus general increases at periods over 270 sec. Gage 46 base and plan data were not directly comparable since the harbor breakwater was not constructed for base test conditions. Plate 166 indicates a fairly high energy level over the range of wave periods tested at gage 46.

PART V: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Tidal circulation study

53. Based on results of the numerical model tidal circulation study of the Deep-Draft Dry Bulk Export Terminal, Alternative No. 6, it is concluded that:

- a. The tidal model simulation revealed no changes in tidal elevation or phase caused by the plan. Therefore, the landfills of the plan did not affect the filling of the harbor, since tide ranges were maintained.
- b. Individual velocity magnitude changes due to the plan were small. The greatest change in velocities at the entrances into the harbor, i.e. Angel's Gate (range 1), Queen's Gate (range 2), and the east entrance (range 3) was at Angel's Gate. The peak flood and ebb velocities were reduced by the plan from 0.76 to 0.55 ft/sec and 0.98 to 0.81 ft/sec, respectively, for a spring tide condition. The decrease in velocity was due to the increased entrance depth (-54 ft NGVD for existing condition, -68 ft NGVD for the plan) and the reduction of surface area in the outer harbor (due to the landfills) served by this entrance channel. It should be noted that while changes were small at other locations in the harbors, velocity magnitudes throughout the harbor are small (less than 1 ft/sec). Percentage changes can be significant and indicate changes in harbor circulation, which are best evaluated by flow volume computations and velocity vector plots presented in this report.
- c. The plan caused only very slight changes in total flow distribution through the three main entrances to the harbors. For flood flow there was a slight decrease due to the plan at Angel's Gate (43.8 to 40.7 percent) and increases at Queen's Gate (28.4 to 29.6 percent) and the east entrance (27.8 to 29.7 percent). For ebb flow the distributions were very nearly the same for existing conditions and the plan, with Angel's Gate being increased 37.8 to 38.3 percent), Queen's Gate percentage of flow being reduced (23.3 to 22.9 percent), and the east entrance very slightly reduced (38.9 to 38.8 percent). These percentage changes reflect changes in the net flow. Net flow at Angel's Gate was reduced by the plan from $+175 \times 10^6$ cu ft to $+69 \times 10^6$ cu ft, both indicating net flow into the harbor at this location. Net flow at Queen's Gate was increased from $+147 \times 10^6$ cu ft to $+188 \times 10^6$ cu ft, both indicating net flow into the harbor. At the eastern entrance to the harbors (range 3) the net flow was reduced from -321×10^6 cu ft to -254×10^6 cu ft, both indicating a net flow from the harbor at this location (the above values represent

spring tide flow conditions but the changes are representative of mean and neap tide conditions).

d. Existing condition data indicated there is a net easterly movement of water mass through the outer harbor region. This net movement decreases with decreasing tidal range. The plan reduced this net flow movement. The reduction was between 21 and 24 percent (depending on tide range).

e. Net circulation in the inner harbor (i.e. Los Angeles Harbor's Main Channel and Long Beach Harbor's Cerritos Channel) showed a reversal from existing conditions. The net circulation for existing conditions is from east to west (i.e. from Long Beach to Los Angeles Harbor). For example, for spring tide conditions, the net flow at range 8B in Cerritos Channel's reversed from $+5 \times 10^6$ cu ft (westerly flow) to -19×10^6 cu ft (easterly flow). Therefore, the plan produces greater flushing of the inner harbor but in the opposite direction of existing conditions. It should be noted that due to the small differences in tidal elevations that govern these flows, other factors not studied here (such as wind) possibly could influence circulation in the back channels (for both existing conditions and the plan).

f. Velocity vector plots provided information on overall circulation patterns. Existing condition patterns were dominated by large horizontal eddies generated by incoming flood flow through Angel's Gate (range 1) and Queen's Gate (range 2). The eddies were strong for spring and mean tide conditions, but only the large central outer harbor eddy was significant during neap tide for existing conditions. Flow patterns at the harbor entrances (Angel's and Queen's Gates) were similar for existing conditions and the plan. The large central eddy gyre in the central harbor area has been eliminated for the plan. However, circulation patterns of currents on the Long Beach side of the island landfill retain some of the characteristics of existing flow conditions, such as easternward flow along the Navy Mole and a westward flow along the outer breakwater. Currents on the Los Angeles south side of the landfill became reversing currents for the plan rather than the unidirectional current of the large eddy that persists for existing conditions.

g. Velocity vector plots illustrated more flow directed toward Los Angeles Harbor's Main Channel, helping to reverse net flow in the back channel region.

h. Dye movement tests indicated that flow from the sewage outfall for existing conditions was initially eastward with most flow circulating in the outer harbor eddy and some entering range 5 into Long Beach Harbor's West Basin. For the plan there was eastward dye movement through the gap between the island landfill and Terminal Island, westward movement toward Fish Harbor, and southward movement toward range 1 along the western face of the island landfill. Dye concentrations in the shallow water habitat were similar for existing and plan conditions over the duration of the simulation.

Harbor resonance study

54. Based on the results of the physical model harbor resonance study of the Deep-Draft Dry Bulk Export Terminal, Alternative No. 6, it is concluded that:

- a. For the proposed terminal locations along the island landfill and on Terminal Island, the resonant peaks were relatively low (wave-height amplifications were usually less than 2.0). The 185-sec wave produced the greatest wave-height amplification (≈5.1) at the inner terminal berths, but only at one location along Terminal Island. The 330-sec wave produced the only significant wave amplification (≈5.4) on the outer (or south) face of the island landfill.
- b. Wave-height amplification in the West Channel of the Port of Los Angeles (gage 10) was reduced for the proposed plan over the major portion of the wave spectrum.
- c. Wave-height amplification in the East Channel of the Port of Los Angeles (gages 2, 3, and 4) indicated no change or some decrease in the maximum wave-height amplifications at each gage.
- d. The two largest amplifications for existing conditions in Southeast Basin were significantly reduced by the plan (from 9 to 4 at 230 sec and from 4.9 to 2.8 at 78 sec) at gages 37 and 39, respectively.
- e. Resonant peaks (that do not occur for existing conditions) would develop in Southeast Basin of the Port of Long Beach with the plan installed but wave amplification factors for these resonant periods are low (all but one less than 3.0 with the one at gage 34 = 4.1).
- f. Wave-height amplification in East Basin and back channel of the Port of Long Beach would not be significantly modified by the plan except for periods over 320 sec, where the maximum amplification of 6 occurred at 350 sec as compared with a value of 2.0 for existing conditions.

Recommendations

55. It is recommended that either a numerical or experimental moored-ship response study be undertaken to adequately quantify moored-ship response in Los Angeles and Long Beach Harbors. The effect of changes in wave-height amplification or a shift in period of maximum amplification cannot readily be evaluated until the response functions of the ships using the harbors are known, nor can frequency and duration of adverse ship mooring be determined without frequency of occurrence data for incident long-period waves. Without ship response data, the effect of changes in resonant oscillations in the harbor must be inferred from comparison with existing conditions and from comparison between various berthing areas in the harbor for existing conditions.

56. It also is recommended that a prototype tidal circulation study be undertaken to provide detailed information on tidal circulation and the effect of wind on this circulation since small differences in tidal elevations (i.e. wind-induced differences) may govern circulation in the back harbor.

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Table 1

Flood and Ebb Flow Volumes*
at Range 9A (10^6 Cu Ft)

Condition	East Flow	West Flow	Net Flow
2020 Plan (1,200 by 76 ft = 91,200 sq ft)	405	24	381
Closed one-third (800 by 76 ft = 60,800 sq ft)	342	21	321 (84 percent)**
Closed two-thirds (400 by 76 ft = 30,400 sq ft)	237	13	224 (59 percent)**
Closed two-thirds and bottom -28 ft (400 by 28 ft = 11,200 sq ft)	172	26	147 (39 percent)**
Sill at -28 ft (1,200 by 28 ft = 33,600 sq ft)	358	32	326 (86 percent)**
Sill at -14 ft (1,200 by 14 ft = 16,800 sq ft)	250	73	177 (46 percent)**

* For 24.4-hr time period, spring tide.
** Percent of 2020 Plan flow.

Table 2

Net Flow Volumes* (10^6 Cu Ft)

Range	2020 Plan	Closed 1/3	Closed 2/3	Closed 2/3 (-28 ft)	Sill (-28 ft)	Sill (-14 ft)
1	228	211	187	162	209	161
2	194	206	224	239	204	233
3	-445	-441	-438	-429	-428	-419
5	-18	-20	-23	-26	-20	-25
8	11	13	16	18	13	18
8A	-15	-17	-20	-22	-14	-22
8B	-14	-16	-19	-22	-14	-22
9A	-381	-321	-224	-147	-326	-177
9B	158	115	46	39	122	28

* For 24.4-hr time period, spring tide.

Table 3

Maximum Velocities (Ft/Sec)

	Existing Conditions			Plan*		
Range	Spring	Mean	Neap	Spring	Mean	Neap
			Maximum Flood Velocities			
1B	0.76	0.64	0.34	0.55	0.48	0.26
2E	0.74	0.59	0.26	0.76	0.61	0.26
3H	0.36	0.31	0.16	0.38	0.32	0.16
5M	0.44	0.33	0.18	0.37	0.33	0.18
8Y	0.26	0.23	0.12	0.27	0.24	0.12
V1	0.28	0.21	0.16	0.09	0.08	0.06
V2	0.07	0.05	0.03	0.16	0.12	0.06
V3	0.30	0.26	0.06	0.47	0.37	0.09
V4	0.60	0.47	0.19	0.25	0.18	0.08
10B	0.05	0.04	0.02	0.09	0.06	0.02
8AP	0.17	0.14	0.08	0.15	0.13	0.07
8BS	0.20	0.16	0.07	0.17	0.14	0.07
			Maximum Ebb Velocities			
1B	0.98	0.78	0.50	0.81	0.62	0.40
2E	0.63	0.48	0.34	0.58	0.46	0.33
3H	0.46	0.39	0.26	0.44	0.38	0.26
5M	0.53	0.43	0.26	0.44	0.38	0.26
8Y	0.37	0.29	0.20	0.38	0.29	0.19
V1	0.12	0.09	0.05	0.75	0.58	0.18
V2	0.35	0.28	0.09	0.45	0.37	0.18
V3	0.29	0.25	0.05	0.42	0.35	0.05
V4	0.21	0.16	0.10	0.14	0.12	0.09
10B	0.20	0.16	0.06	0.16	0.12	0.05
8AP	0.23	0.18	0.12	0.24	0.19	0.11
8BS	0.16	0.14	0.09	0.19	0.15	0.09

* Plan = alternate Plan No. 6.

Table 4

Maximum Tidal Discharges (Cu Ft/Sec)

Range	Spring Tide Existing Conditions	Spring Tide Plan*	Mean Tide Existing Conditions	Mean Tide Plan*	Neap Tide Existing Conditions	Neap Tide Plan*
			Flood Flow Discharges			
1	103,056	92,361	84,722	75,417	41,250	38,611
2	70,000	70,417	52,639	53,750	25,694	25,556
3	68,056	71,111	56,944	59,583	32,083	32,222
5	27,083	25,833	21,528	20,972	11,222	11,097
8	13,306	14,583	10,875	11,444	5,556	5,694
8A	11,167	9,931	8,597	8,069	4,542	4,389
8B	6,292	5,042	4,694	4,167	2,514	2,375
10	4,569	7,125	3,319	4,833	2,319	2,125
11	429	1,778	274	1,375	158	685
12	34,028	35,972	27,083	27,500	16,250	17,500
13	3,028	6,458	2,111	4,111	1,958	2,625
			Ebb Flow Discharges			
1	101,944	100,417	79,583	78,194	54,028	51,667
2	65,417	62,361	50,833	48,611	34,306	33,611
3	92,639	89,167	74,722	72,361	48,611	47,778
5	28,611	29,167	22,778	23,194	15,417	15,417
8	15,000	14,306	11,792	11,333	7,903	7,736
8A	11,375	11,681	9,181	9,625	6,250	6,236
8B	6,153	6,819	5,028	5,472	3,417	3,444
10	16,250	12,403	10,903	9,375	7,861	7,167
11	2,986	5,153	2,417	4,319	840	2,128
12	9,917	26,806	6,042	22,500	6,111	12,708
13	12,556	5,986	8,792	5,347	5,514	4,347

* Plan = alternate Plan No. 6.

Table 5

Average Flow Volume for One Tidal Cycle (10^6 Cu Ft)

Range	Spring Tide Existing*	Spring Tide Plan	Spring Tide Difference	Mean Tide Existing	Mean Tide Plan	Mean Tide Difference	Neap Tide Existing	Neap Tide Plan	Neap Tide Difference
Flood Flow Volumes									
1	1,273	1,147	(-126)	1,087	977	(-110)	476	417	(-59)
2	824	833	(+9)	668	678	(+10)	281	292	(+11)
3	809	836	(+27)	684	707	(+23)	283	298	(+15)
5	323	309	(-14)	270	260	(-10)	114	111	(-3)
8	162	176	(+14)	138	148	(+10)	58	62	(+4)
8A	132	118	(-14)	109	99	(-10)	46	43	(-3)
8B	74	60	(-14)	60	50	(-10)	26	22	(-4)
10	0	8	(+8)	1	6	(+5)	7	15	(+8)
11	0	1	(+1)	0	0	(0)	1	2	(+1)
12	589	390	(-199)	463	311	(-152)	174	129	(-45)
13	3	37	(+34)	0	24	(+24)	2	16	(+14)
Ebb Flow Volumes									
1	1,098	1,078	(-20)	905	888	(-17)	390	378	(-12)
2	677	645	(-32)	573	548	(-25)	251	243	(-8)
3	1,130	1,090	(-40)	953	920	(-33)	393	381	(-12)
5	317	328	(+11)	269	275	(+7)	114	115	(+1)
8	167	157	(-10)	139	132	(-7)	58	58	(0)
8A	127	137	(+10)	108	115	(+7)	46	47	(+1)
8B	69	79	(+10)	59	66	(+7)	26	27	(+1)
10	321	263	(-58)	272	223	(-49)	119	100	(-19)
11	81	106	(+25)	45	88	(+43)	18	38	(+20)
12	15	335	(+320)	22	296	(+274)	11	127	(+116)
13	182	87	(-95)	181	96	(-85)	85	48	(-37)

* Existing = existing conditions.
Plan = outer harbor landfill configuration Alternative No. 6.
Difference = existing condition flow volume minus plan flow volume.

Table 6

Average Net Flow Volumes for One Tidal Cycle (10^6 Cu Ft)

	Spring Tide		Mean Tide		Neap Tide	
Range	Existing	Plan	Existing	Plan	Existing	Plan
1	175	69	182	89	86	39
2	147	188	95	130	30	49
3	-321	-254	-269	-213	-110	-83
5	6	-19	1	-15	0	-4
8	-5	19	-1	16	0	4
8A	5	-19	1	-16	0	-4
8B	5	-19	1	-16	0	-5
10	-321	-255	-272	-217	-112	-85
11	-81	-105	-45	-88	-17	-36
12	574	55	441	15	163	2
13	-179	-50	-181	-72	-83	-32

Note: Negative (-) net volume indicates net ebb flow; positive net volume indicates net flood flow (flow direction is defined in Figure 6).
Existing = existing conditions.
Plan = outer harbor landfill configuration Alternative No. 6.

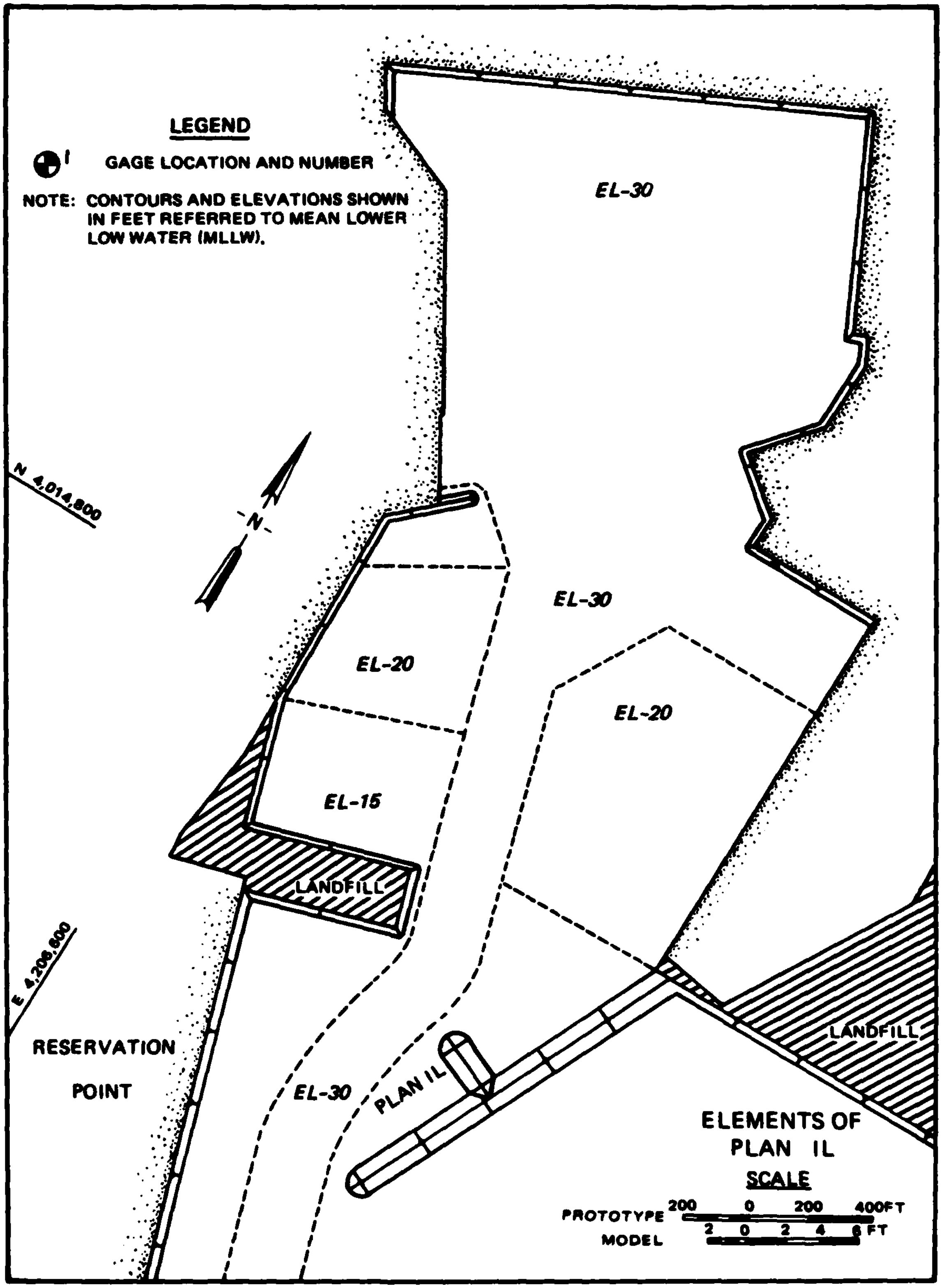
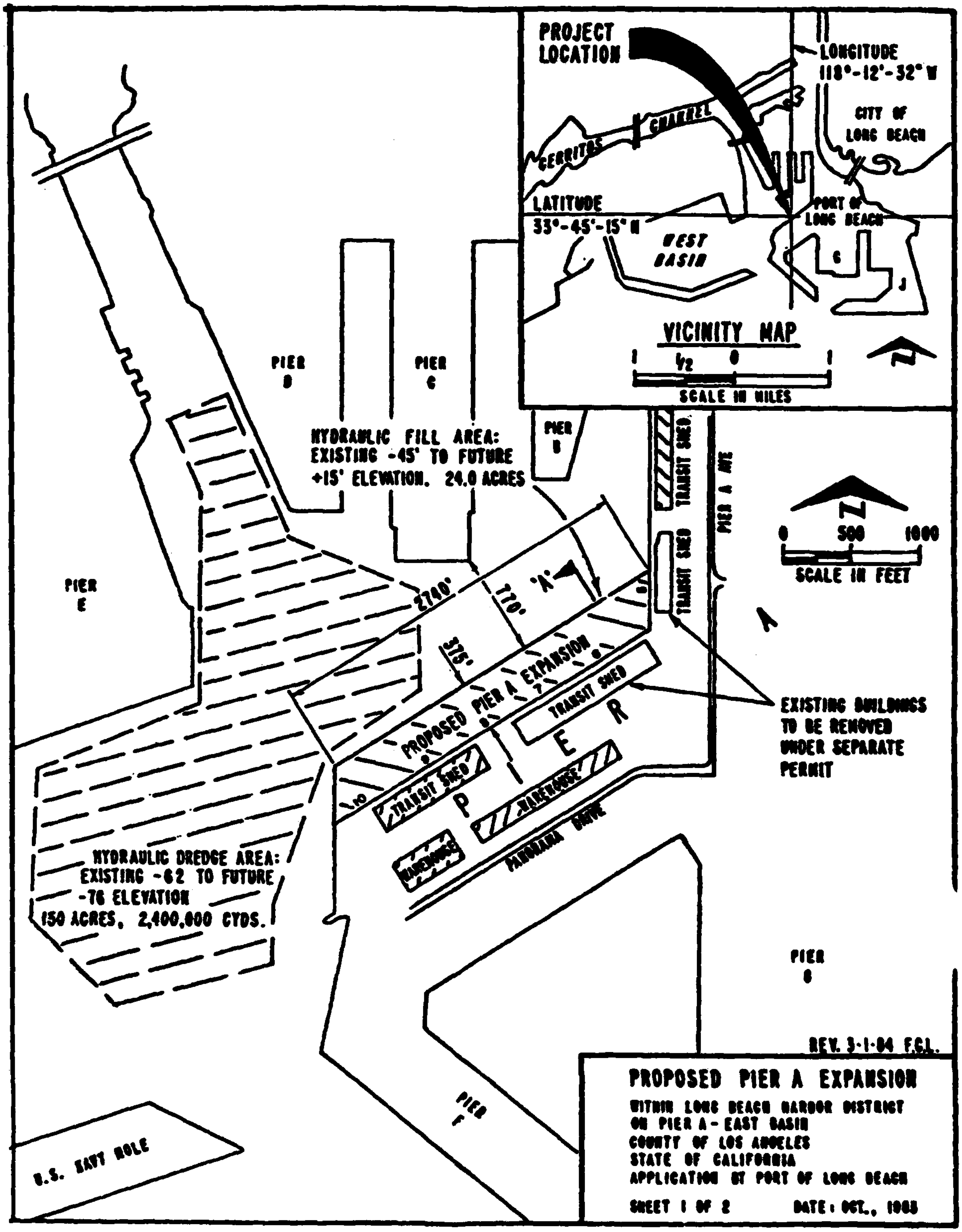

LEGEND
GAGE LOCATION AND NUMBER
NOTE: CONTOURS AND ELEVATIONS SHOWN IN FEET REFERRED TO MEAN LOWER LOW WATER (MLLW).
EL-30
EL-30
EL-20
EL-20
EL-15
LANDFILL
LANDFILL
N 4,014,800
E 4,206,600
N
RESERVATION POINT
EL-30
PLAN IL
ELEMENTS OF PLAN IL
SCALE
PROTOTYPE 200 0 200 400 FT
MODEL 2 0 2 4 6 FT

PLATE 1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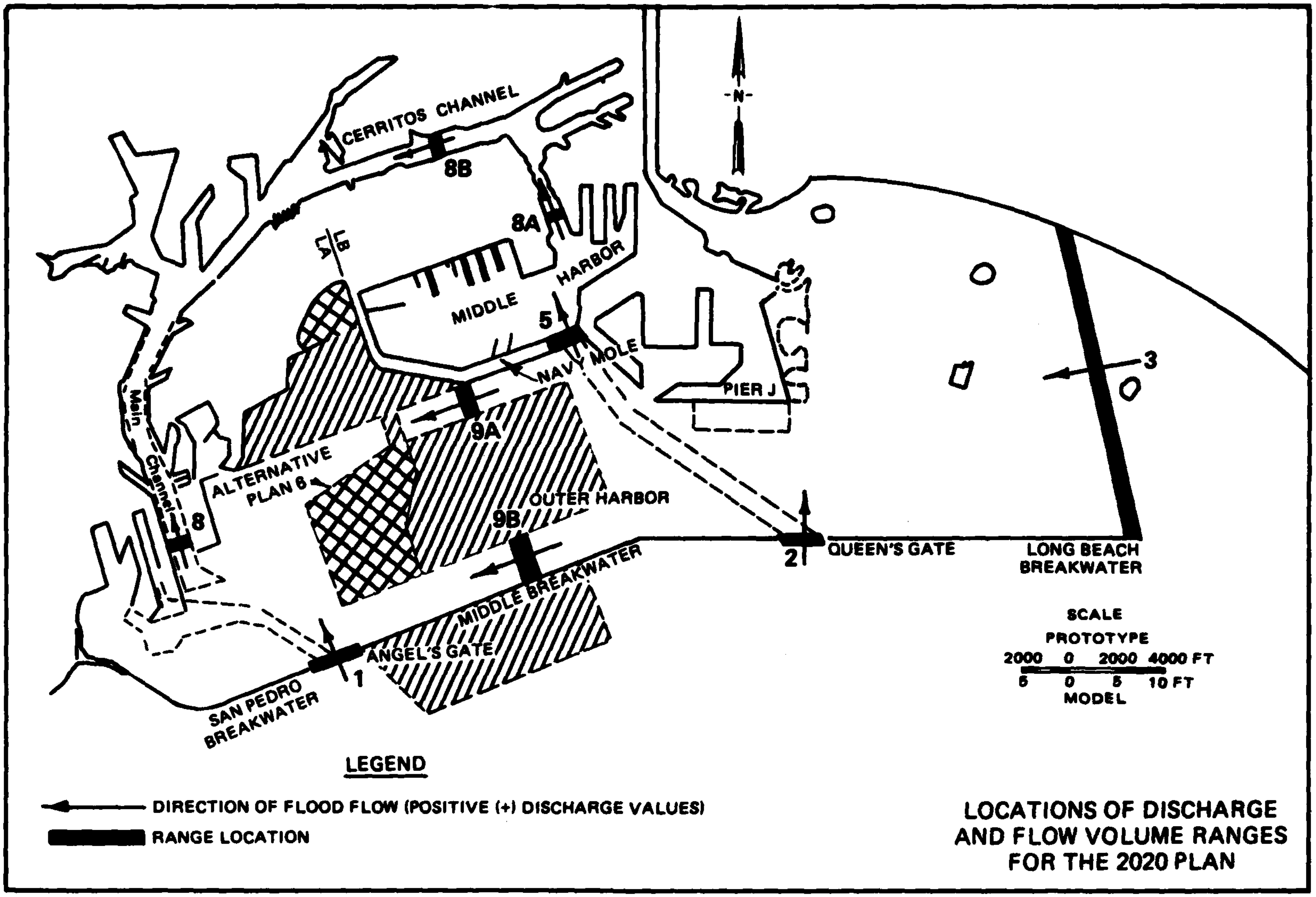
LONGITUDE 118°-12'-32" W
CERRITOS CHANNEL
CITY OF LONG BEACH
LATITUDE 33°-45'-15" N
WEST BASIN
PORT OF LONG BEACH
VICINITY MAP
SCALE IN MILES
PIER D
PIER C
PIER B
PIER E
HYDRAULIC FILL AREA: EXISTING -45' TO FUTURE +15' ELEVATION. 24.0 ACRES
TRANSIT SHED
PIER A AVE
0 500 1000
SCALE IN FEET
2740'
770'
315'
PROPOSED PIER A EXPANSION
TRANSIT SHED
WAREHOUSE
PIER
PANORAMA DRIVE
EXISTING BUILDINGS TO BE REMOVED UNDER SEPARATE PERMIT
HYDRAULIC DREDGE AREA: EXISTING -62 TO FUTURE -76 ELEVATION
150 ACRES, 2,400,000 CYDS.
PIER G
PIER F
U.S. NAVY MOLE
REV. 3-1-84 F.C.L.
PROPOSED PIER A EXPANSION
WITHIN LONG BEACH HARBOR DISTRICT
ON PIER A - EAST BASIN
COUNTY OF LOS ANGELES
STATE OF CALIFORNIA
APPLICATION BY PORT OF LONG BEACH
SHEET 1 OF 2 DATE: OCT., 1983

PLATE 2



LOCATIONS OF DISCHARGE AND FLOW VOLUME RANGES FOR THE 2020 PLAN

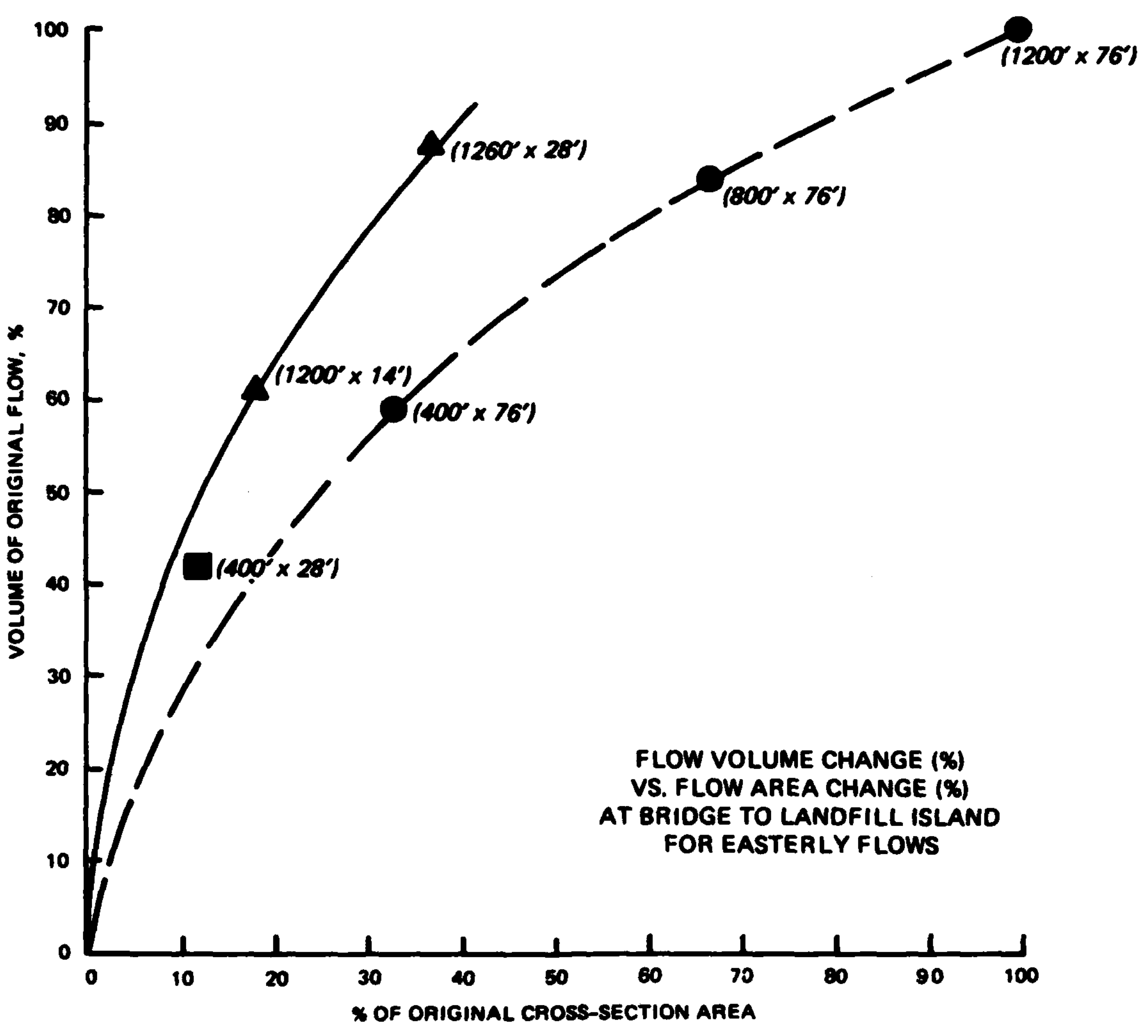

100
90
80
70
60
50
40
30
20
10
0
VOLUME OF ORIGINAL FLOW, %
0
10
20
30
40
50
60
70
80
90
100
% OF ORIGINAL CROSS-SECTION AREA
(1200' x 76')
(1260' x 28')
(800' x 76')
(1200' x 14')
(400' x 76')
(400' x 28')
FLOW VOLUME CHANGE (%)
VS. FLOW AREA CHANGE (%)
AT BRIDGE TO LANDFILL ISLAND
FOR EASTERLY FLOWS

PLATE 4

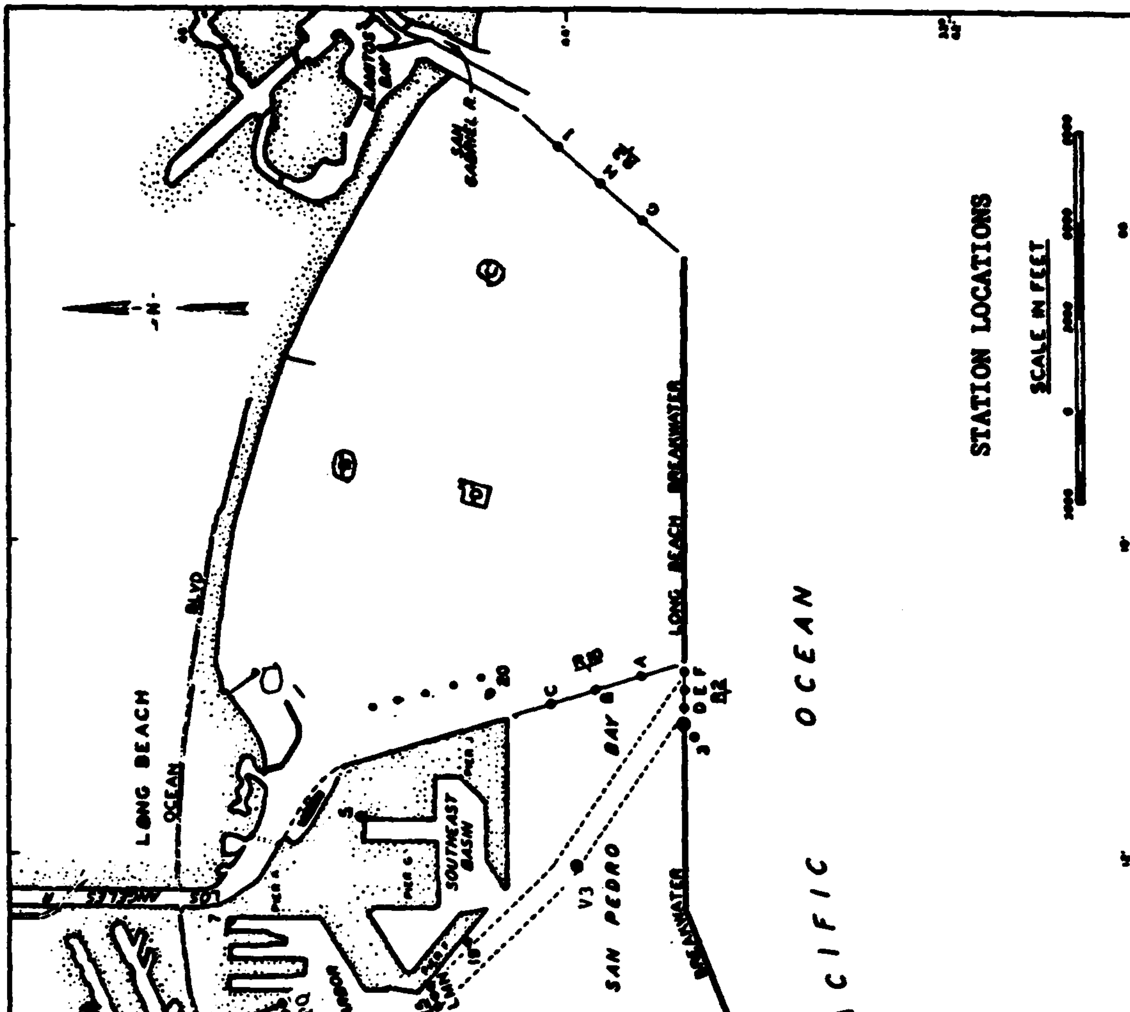
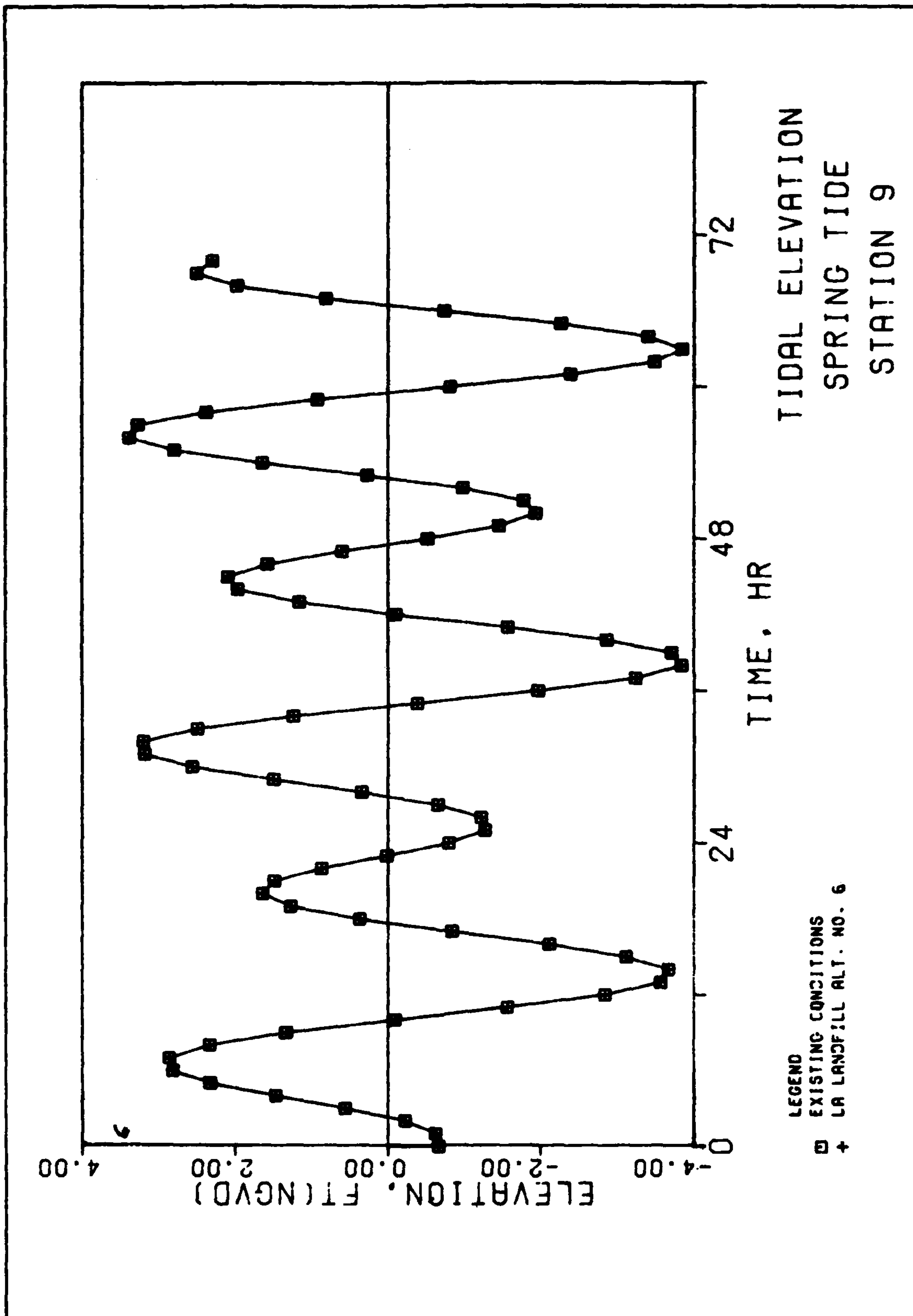

STATION LOCATIONS
SCALE IN FEET
LEGEND
TIDE GAGE
VELOCITY STATION
RANGE 2
LOS ANGELES
LONG BEACH
OCEAN BLVD
PACIFIC OCEAN
SAN PEDRO BAY
LONG BEACH HARBOR
SOUTHEAST BASIN
TERMINAL ISLAND
SEASIDE BLVD
CERRITOS CHANNEL
MAIN CHANNEL
WEST BASIN
SAN PEDRO
LONG BEACH BREAKWATER
MIDDLE BREAKWATER
SAN PEDRO BREAKWATER
SEWAGE OUTFALL
SAN GABRIEL R.
V1
V2
V3
V4

PLATE 5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SPRING TIDE
STATION 9
TIME, HR
ELEVATION, FT(NGVD)
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24
48
72
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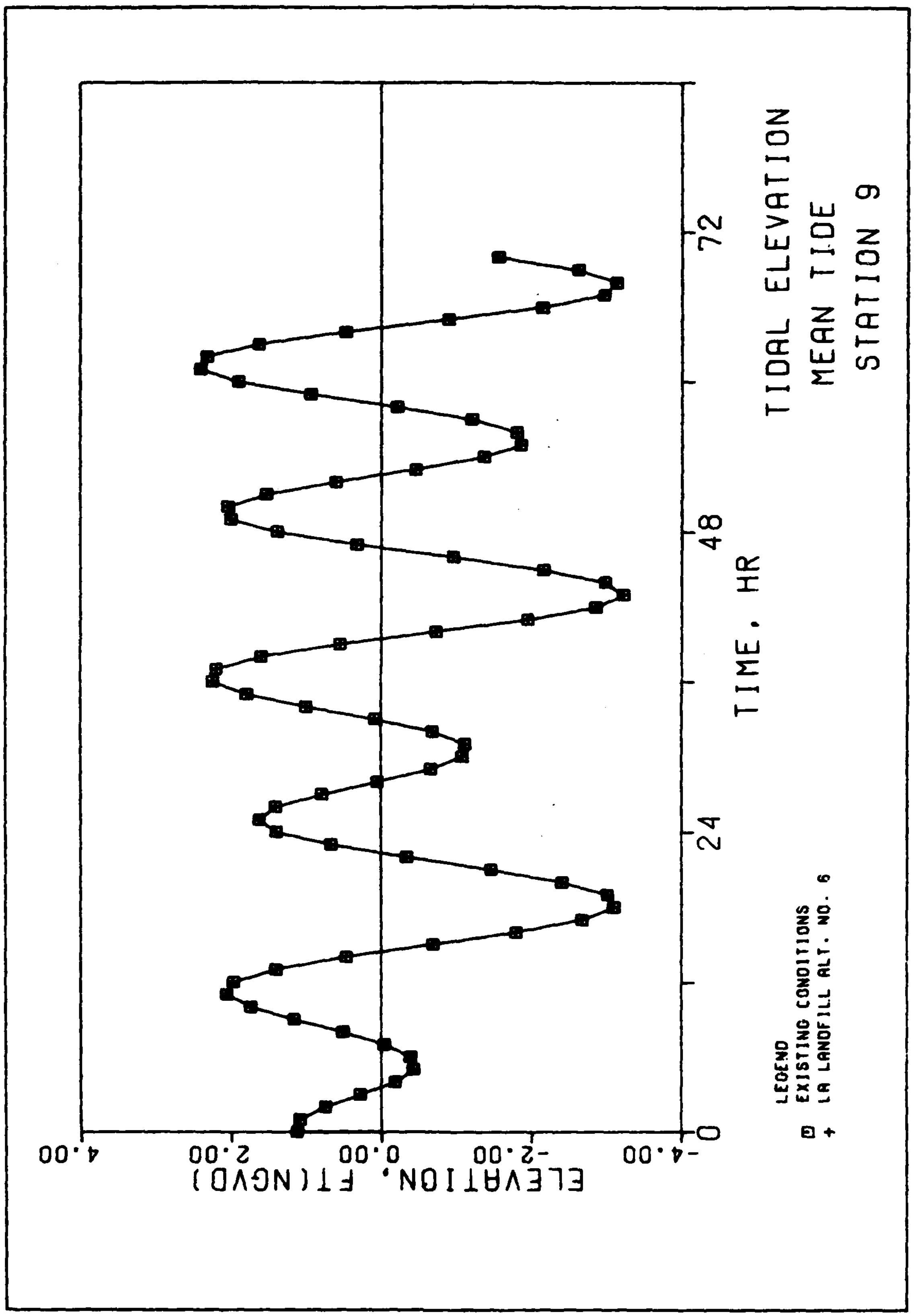
-2.00
0.00
2.00
4.00
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 6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MEAN TIDE
STATION 9
TIME, HR
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24
48
72
ELEVATION, FT(NGVD)
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2.00
4.00
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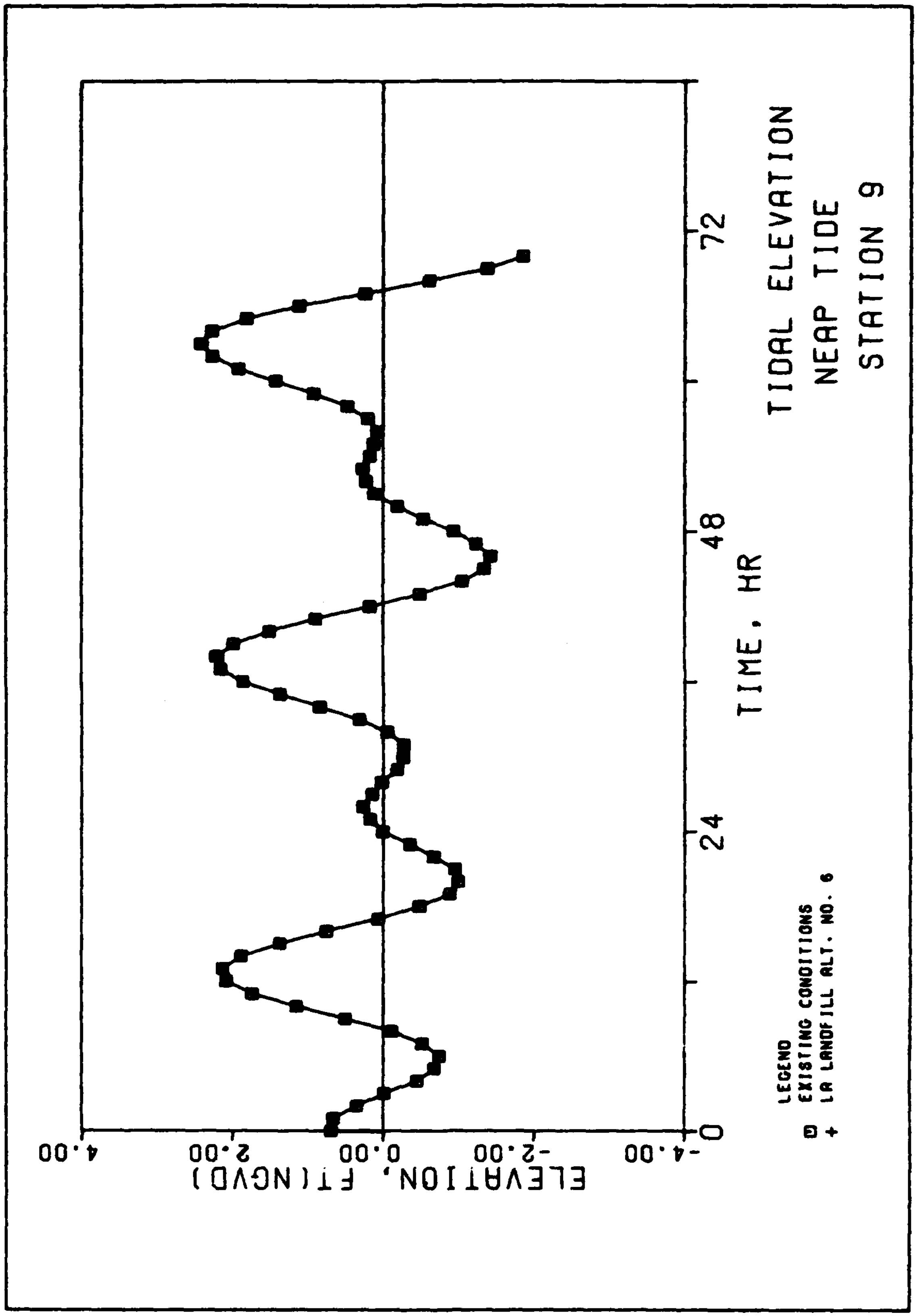
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6


TIDAL ELEVATION
NEAP TIDE
STATION 9
TIME, HR
ELEVATION, FT(NGVD)
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72
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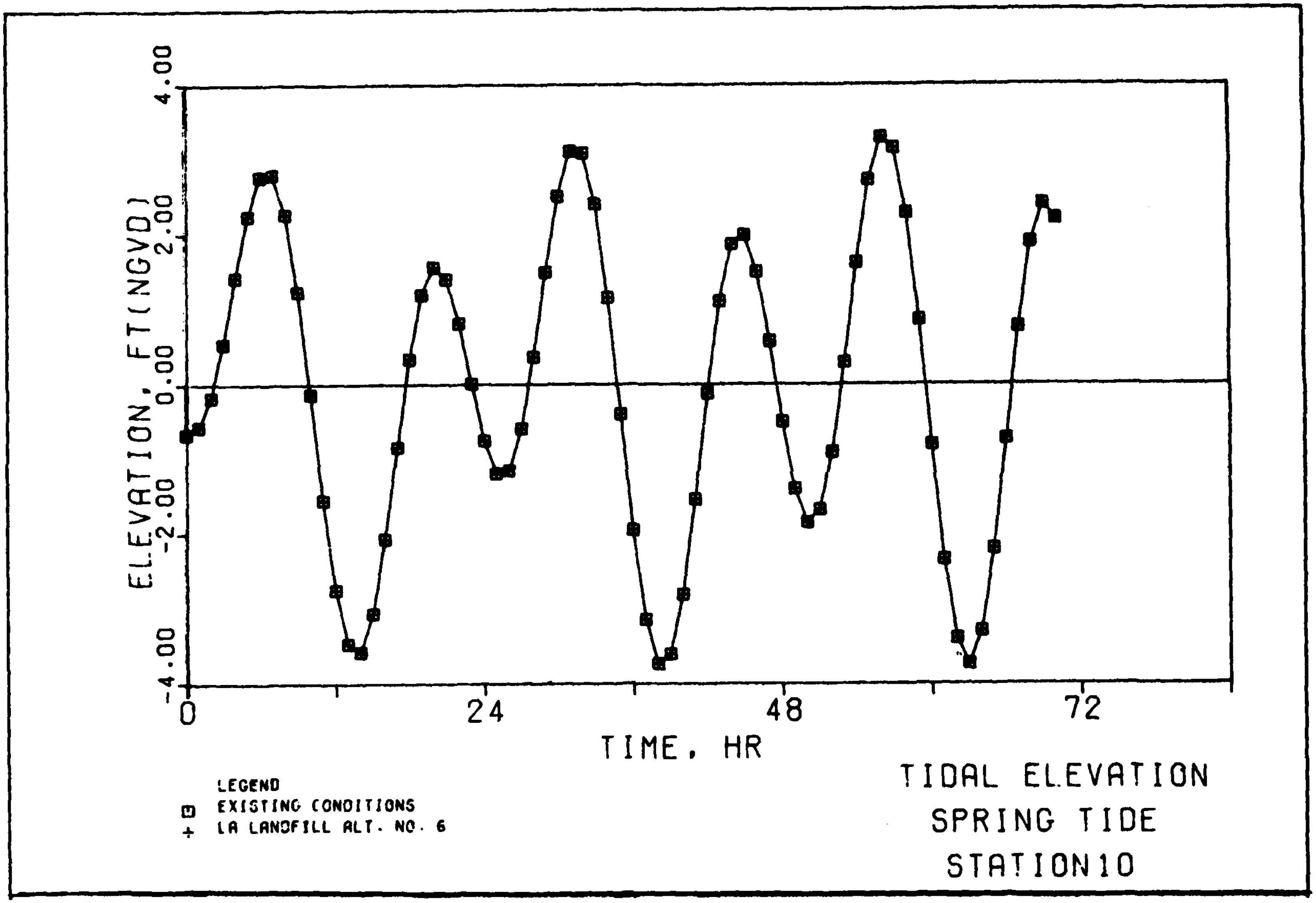
0.00
2.00
4.00
LEGEND
EXISTING CONDITIONS
LR LANDFILL ALT. NO. 6

PLATE 8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ELEVATION, FT(NGVD)
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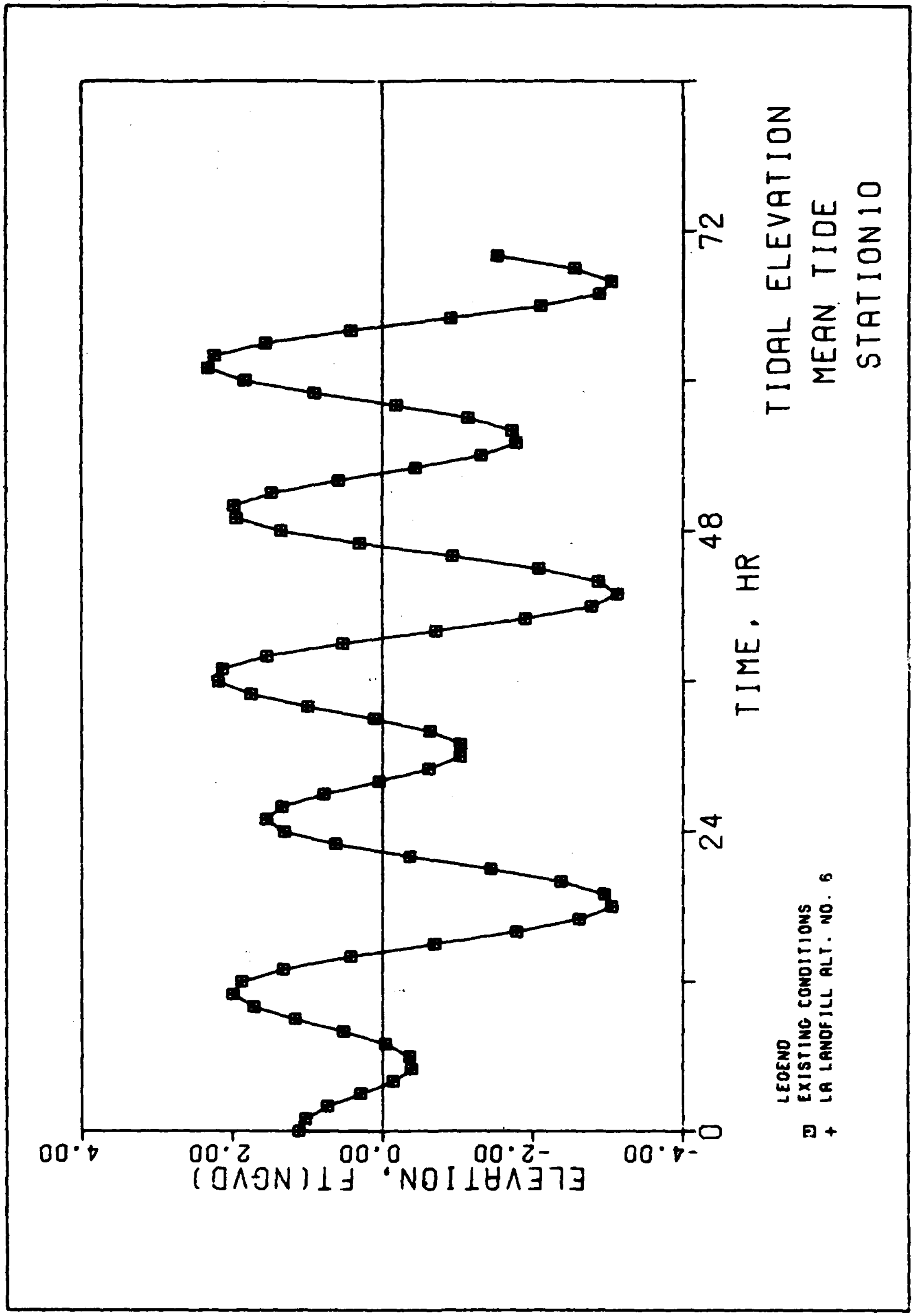
48
72
TIME, HR
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6
TIDAL ELEVATION
SPRING TIDE
STATION10

PLATE 9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MEAN TIDE
STATION10
ELEVATION, FT(NGVD)
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-2.00
-4.00
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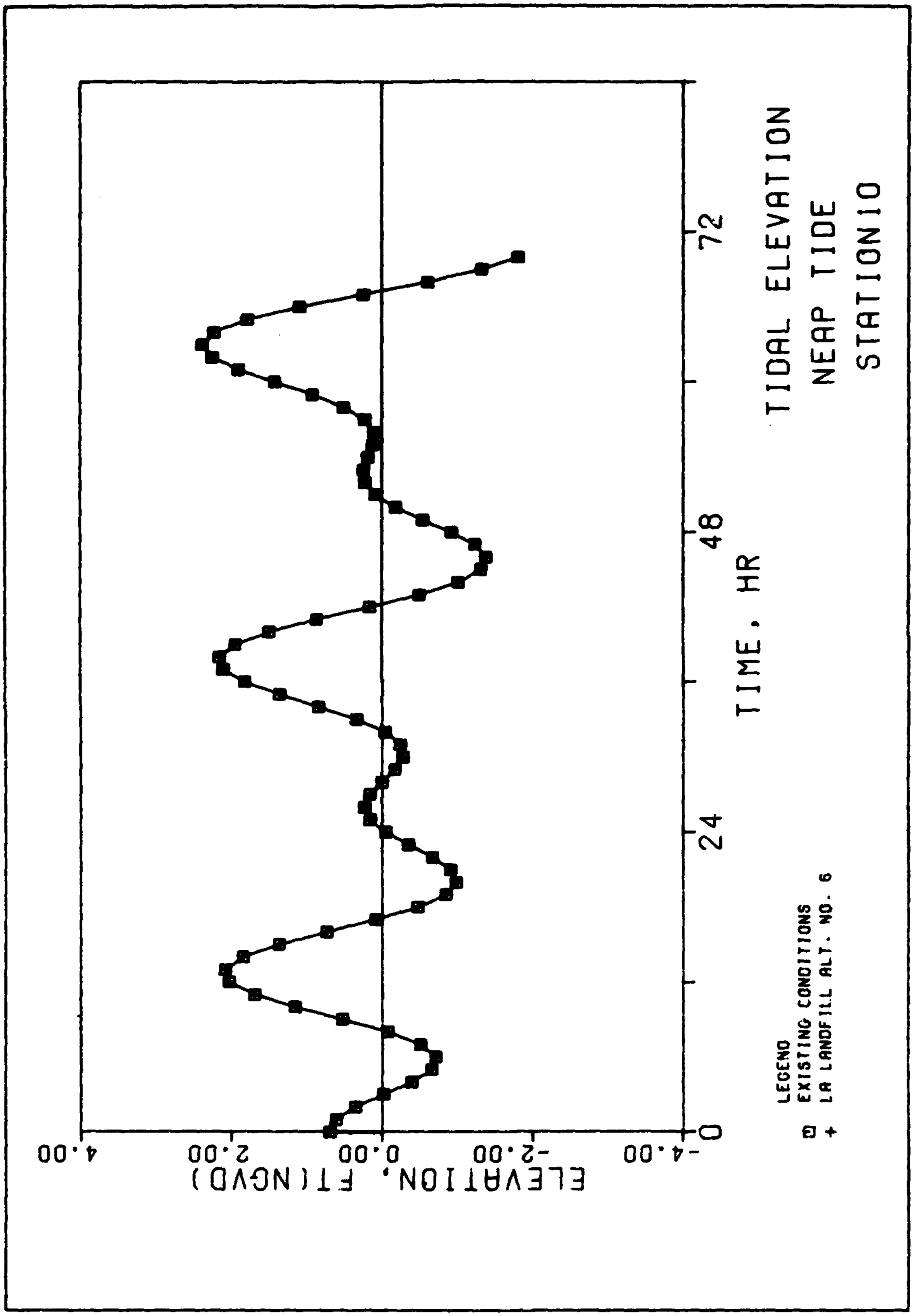
24
48
72
TIME, HR
LEGEND
EXISTING CONDITIONS
+ LA LANDFILL ALT. NO. 6

PLATE 10


TIDAL ELEVATION
NEAP TIDE
STATION10
TIME, HR
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48
72
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4.00
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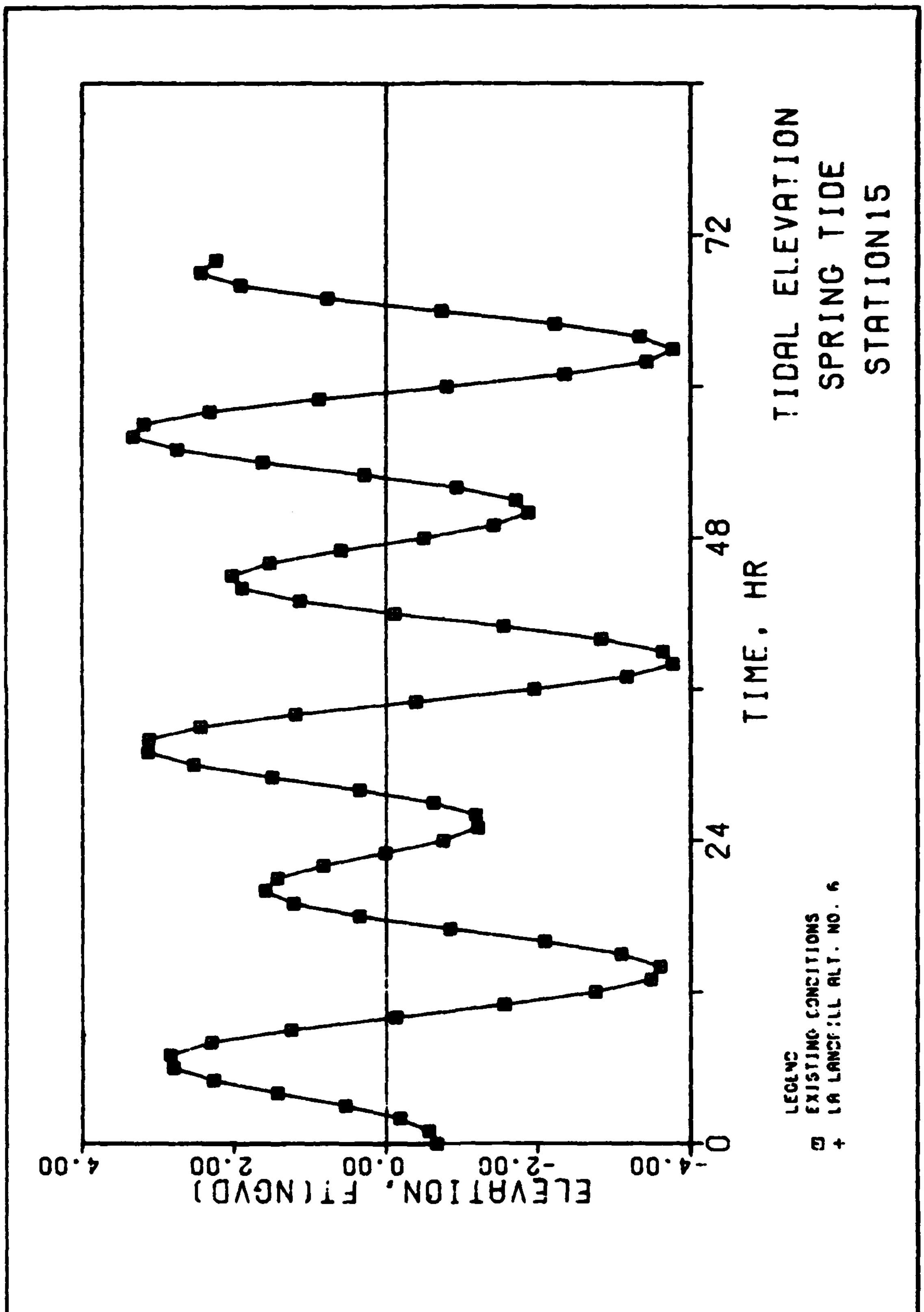
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6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SPRING TIDE
STATION15
TIME, HR
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48
72
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4.00
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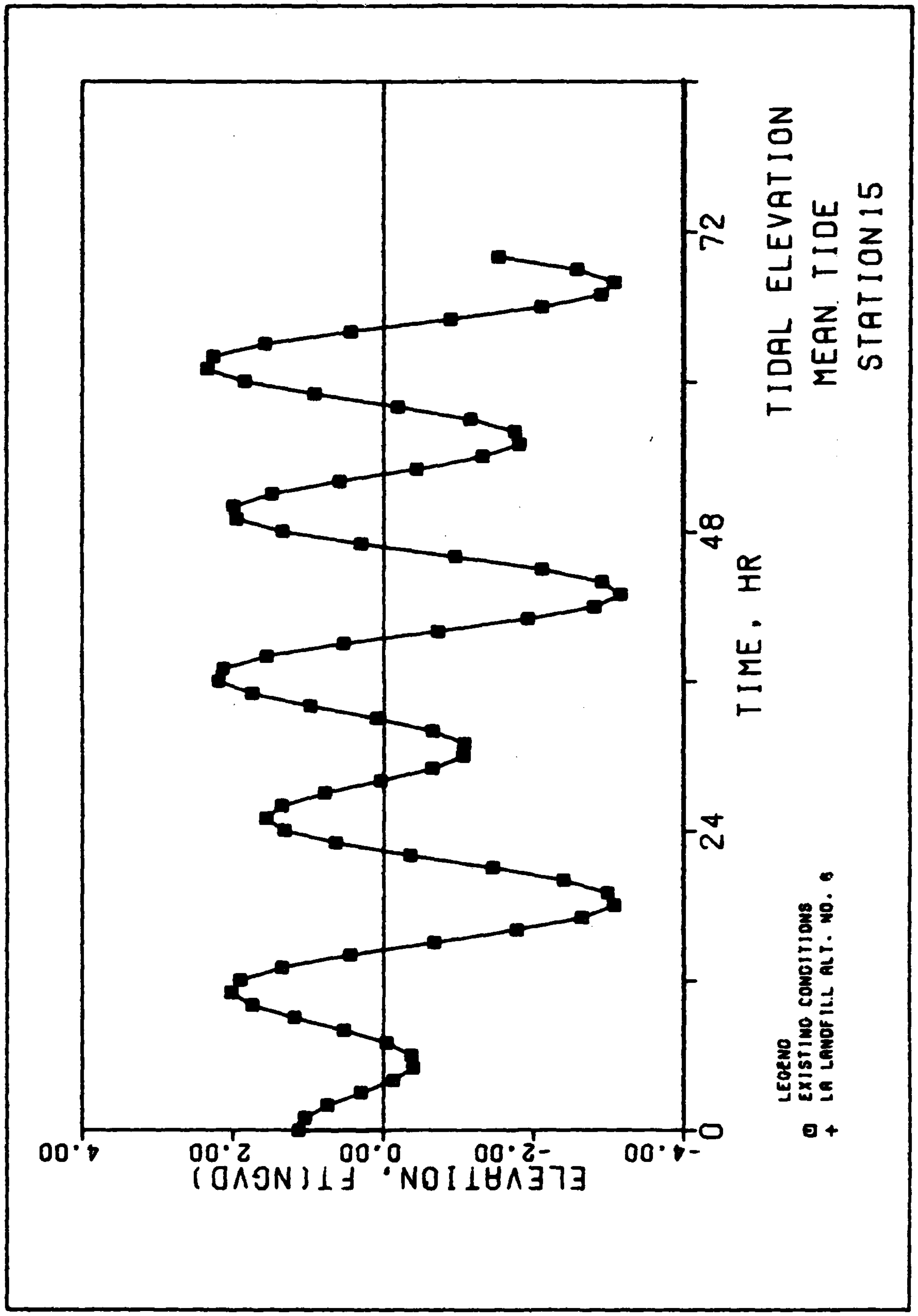
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 12



TIDAL ELEVATION
MEAN TIDE
STATION15
TIME, HR
ELEVATION, FT(NGVD)
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24
48
72
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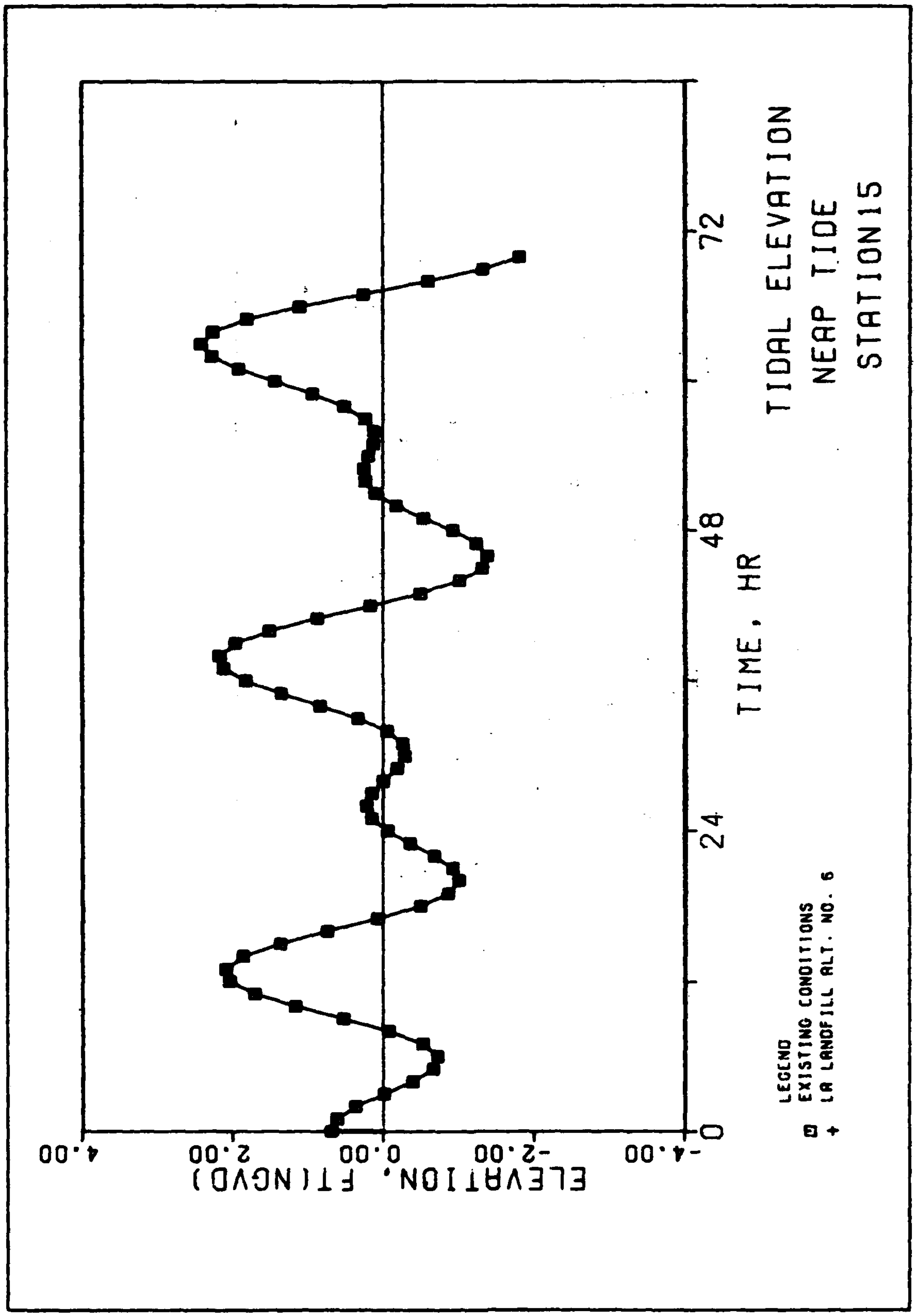
-2.00
0.00
2.00
4.00
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 13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NEAP TIDE
STATION15
TIME, HR
ELEVATION, FT(NGVD)
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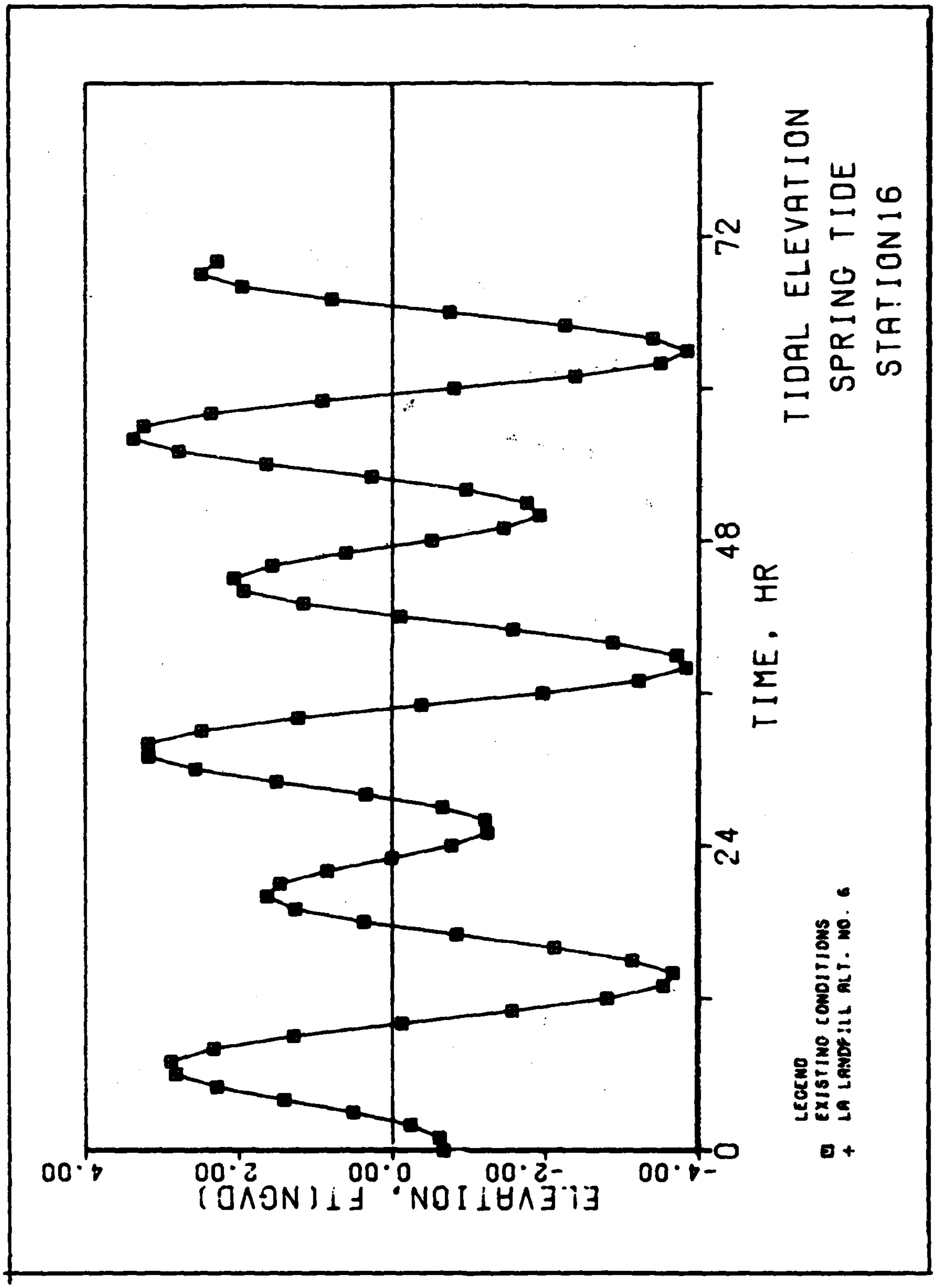
-4.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 14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SPRING TIDE
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4.00
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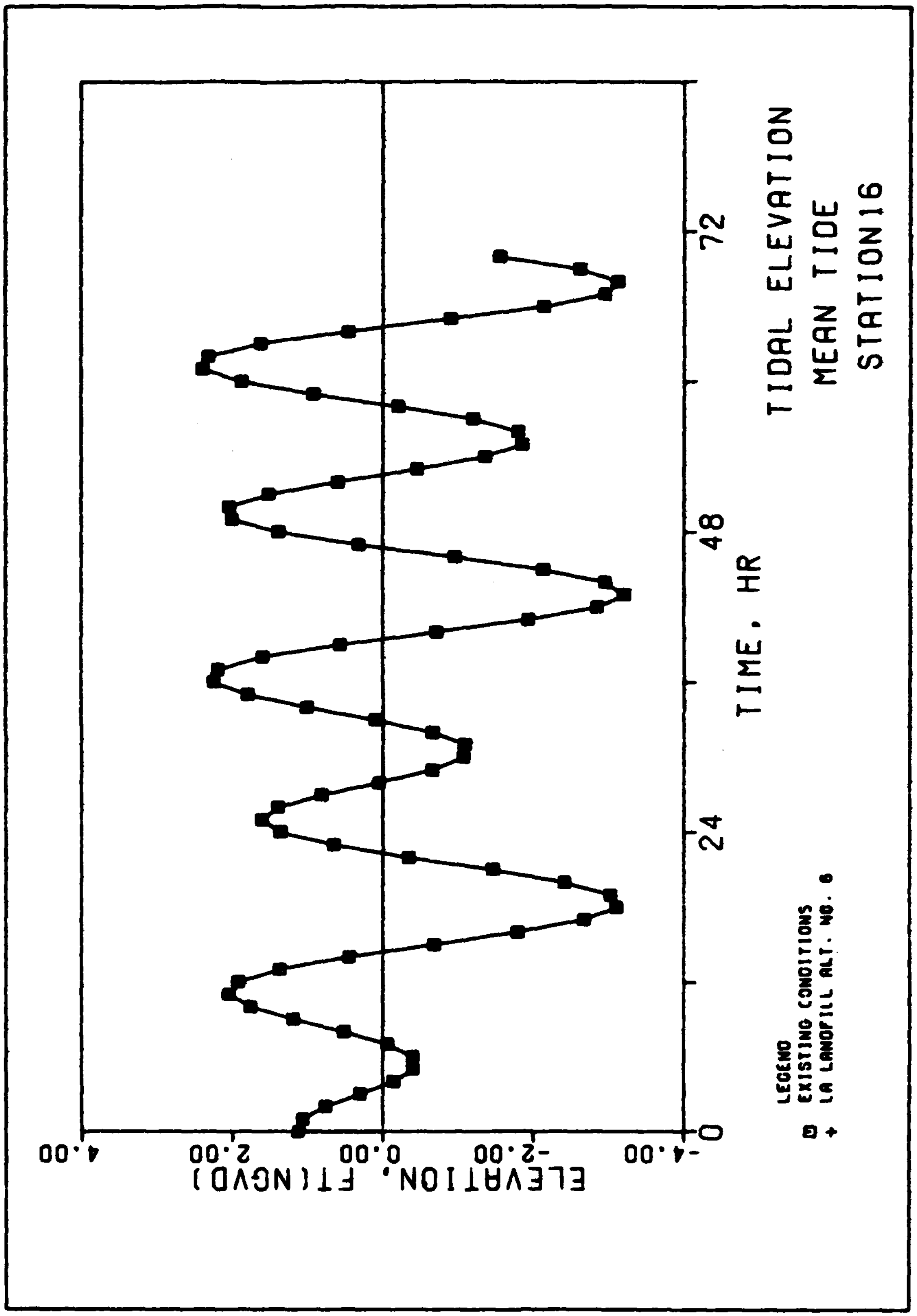
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 15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MEAN TIDE
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ELEVATION, FT(NGVD)
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48
72
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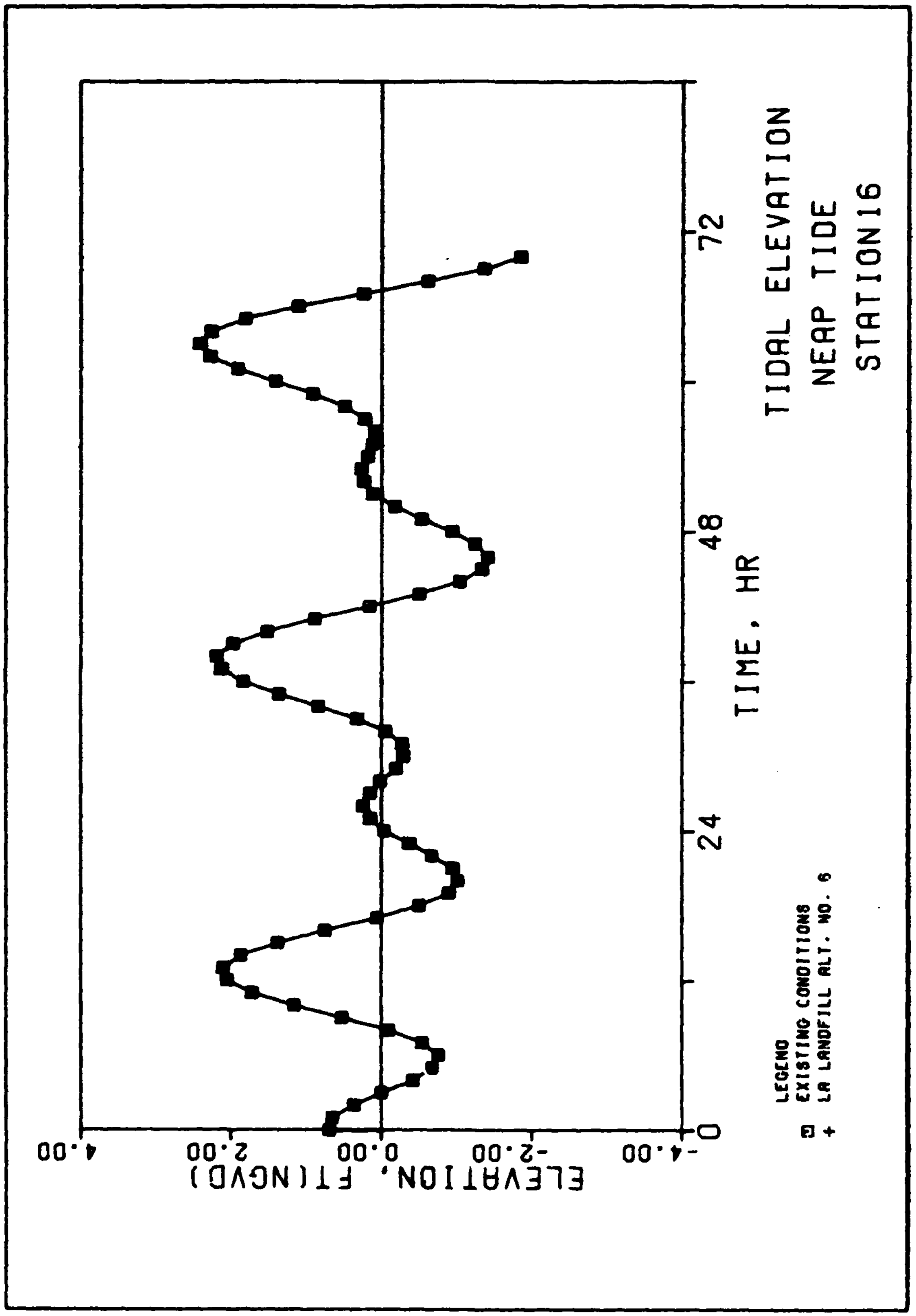
2.00
4.00
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 16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NEAP TIDE
STATION16
TIME, HR
ELEVATION, FT(NGVD)
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-2.00
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4.00
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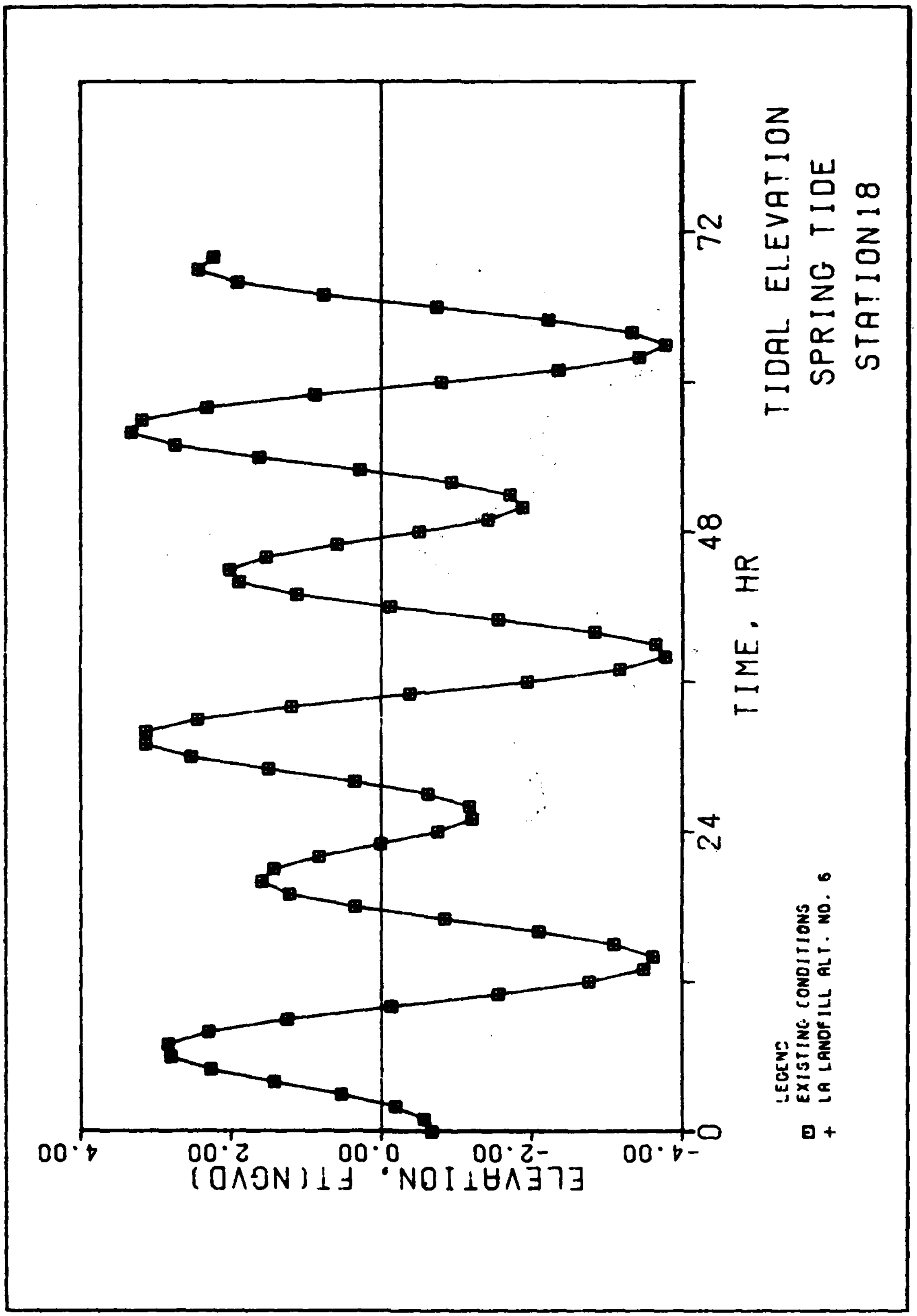
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 17

60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SPRING TIDE
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72
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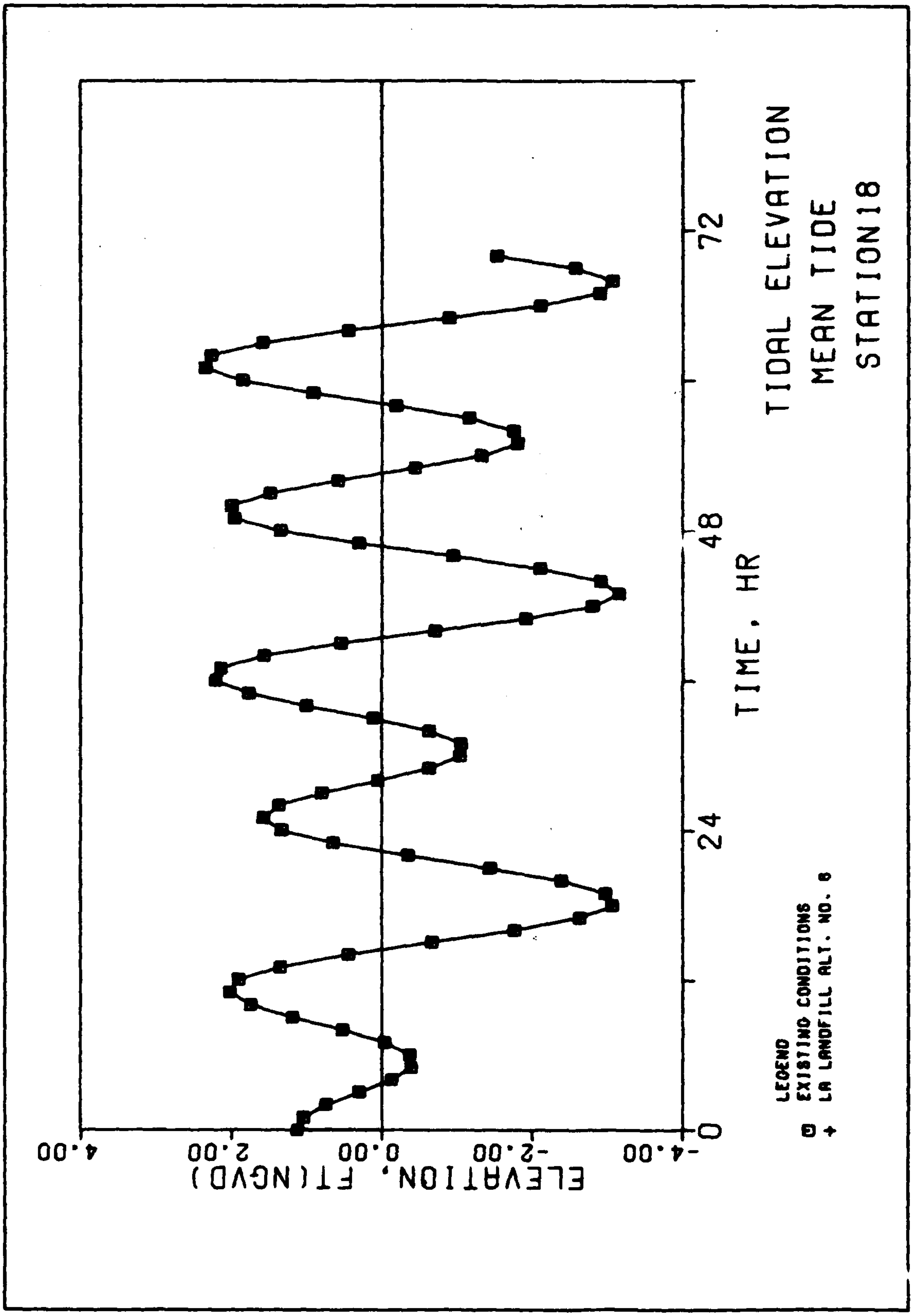
4.00
LEGEND
EXISTING CONDITIONS
+ LA LANDFILL ALT. NO. 6

PLATE 18



TIDAL ELEVATION
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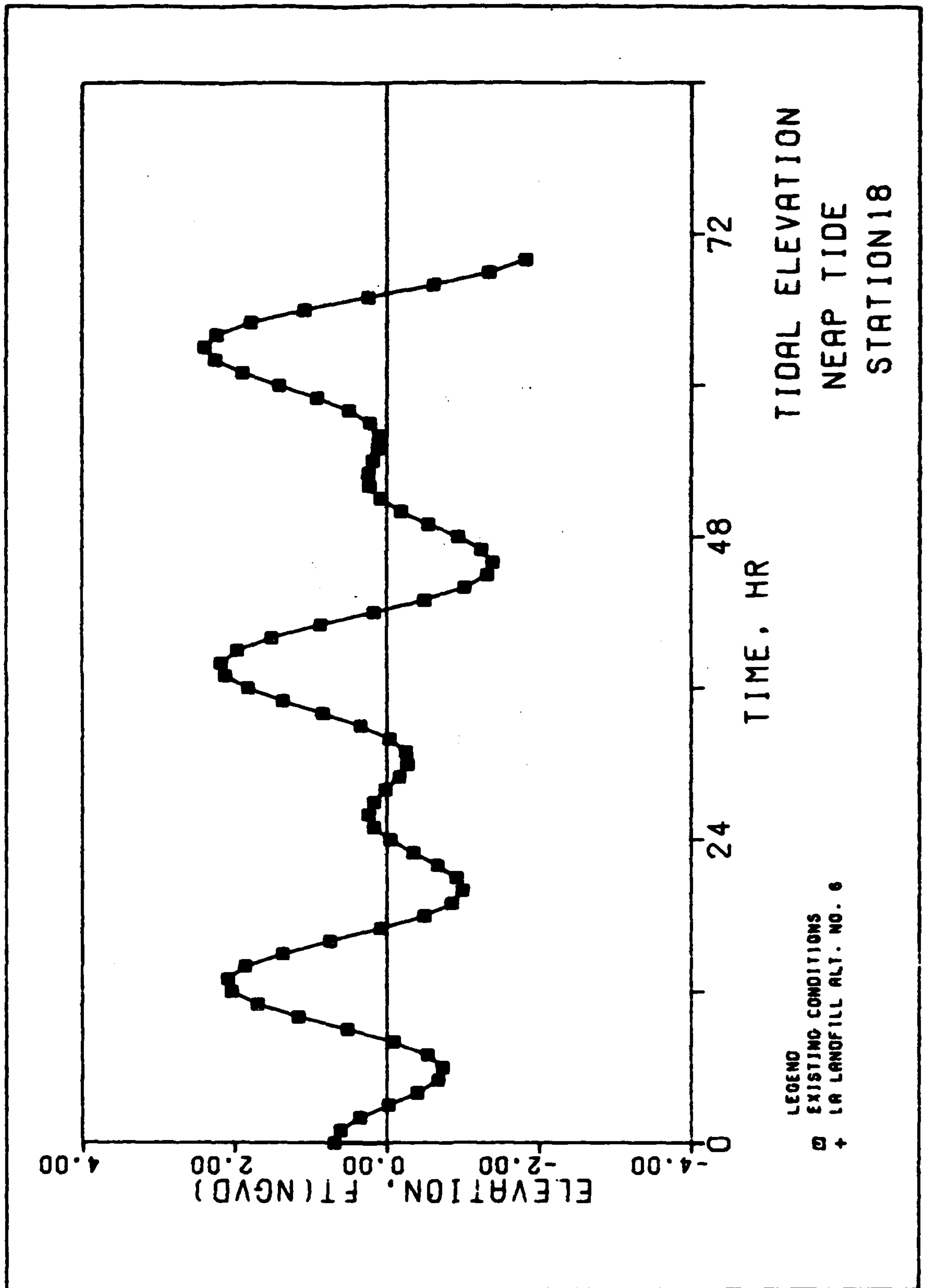
ELEVATION, FT(NGVD)
-4.00
-2.00
0.00
2.00
4.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6


TIDAL ELEVATION
NEAP TIDE
STATION18
TIME, HR
ELEVATION, FT(NGVD)
0
24
48
72
-4.00
-2.00
0.00
2.00
4.00
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

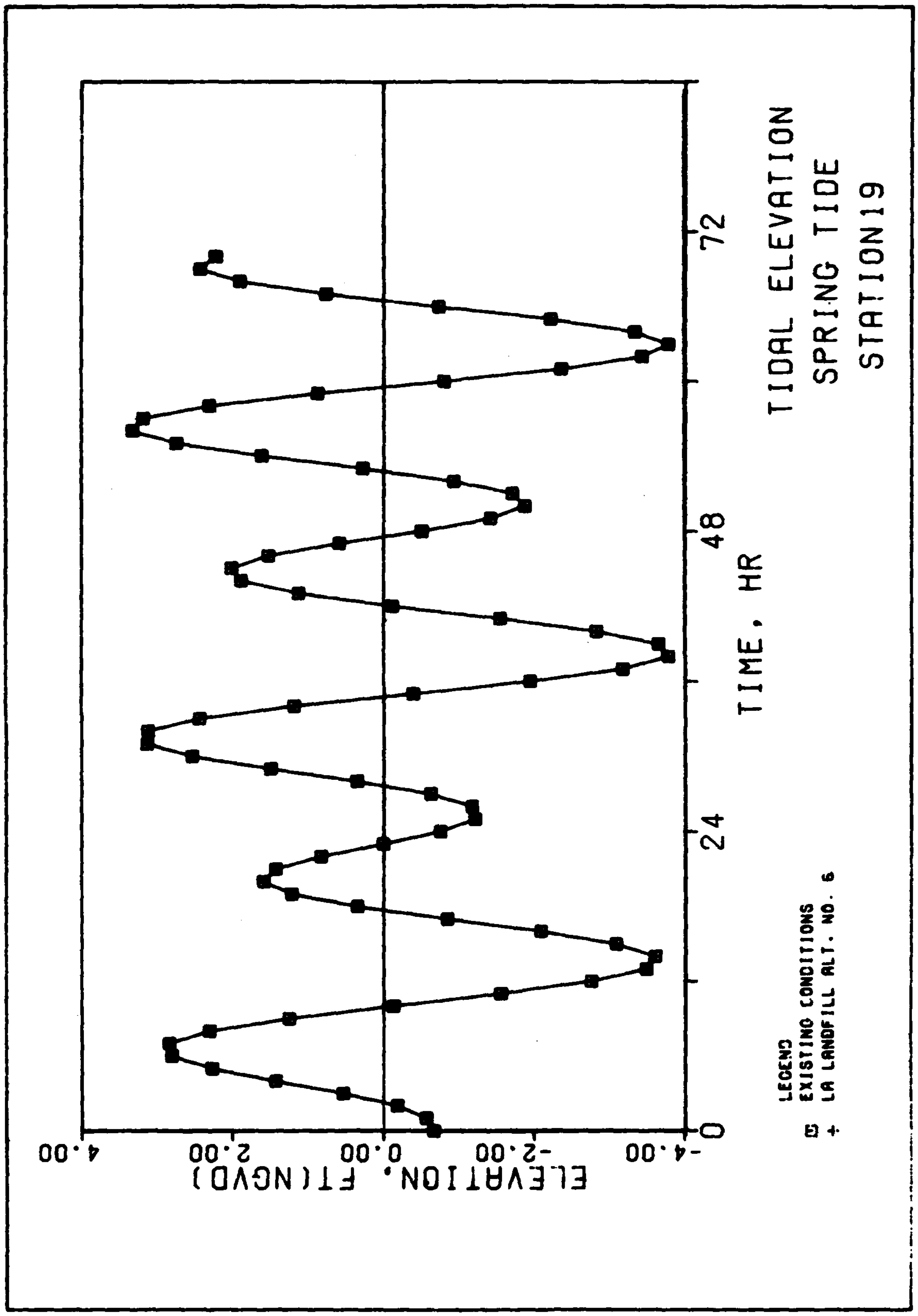
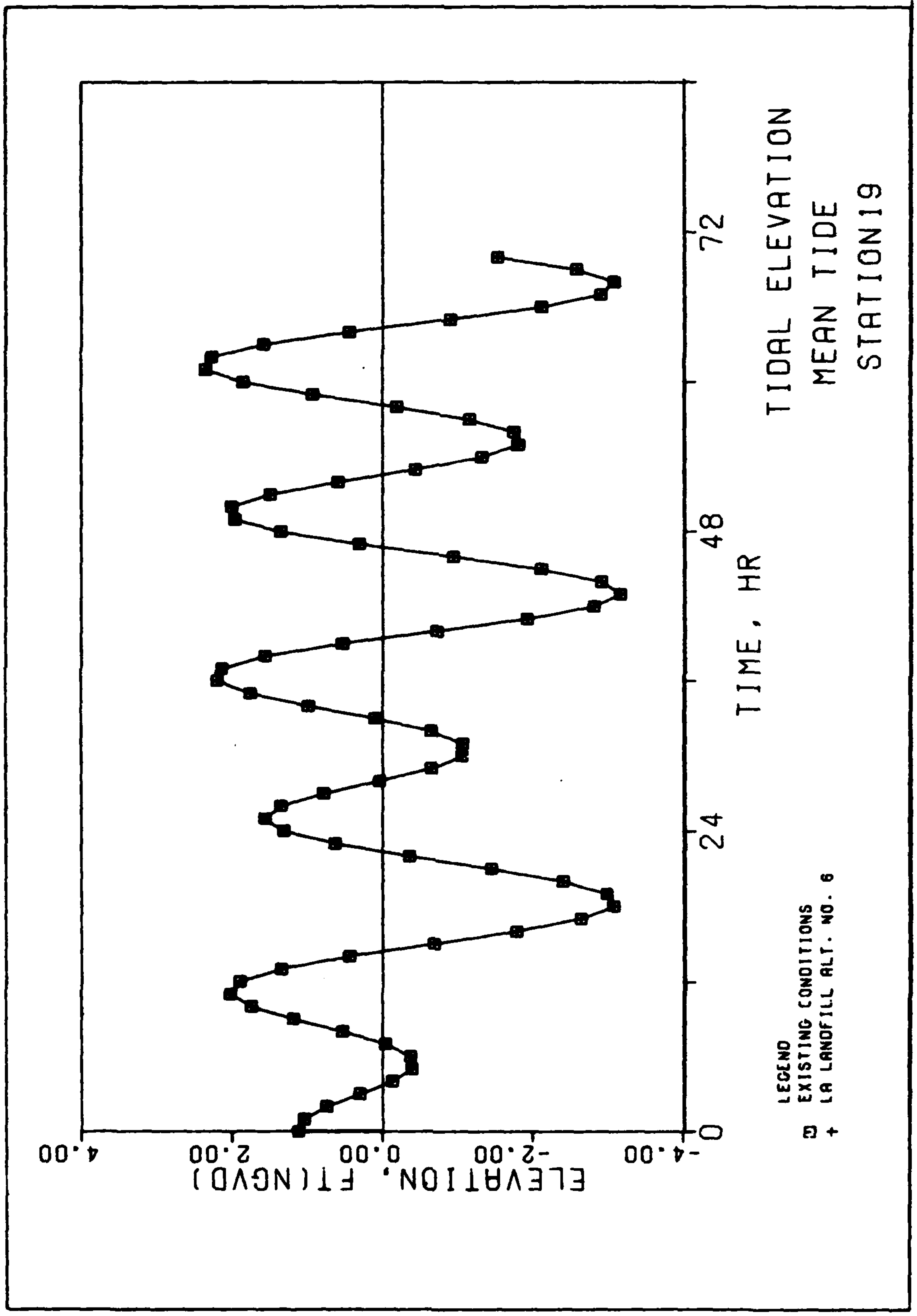
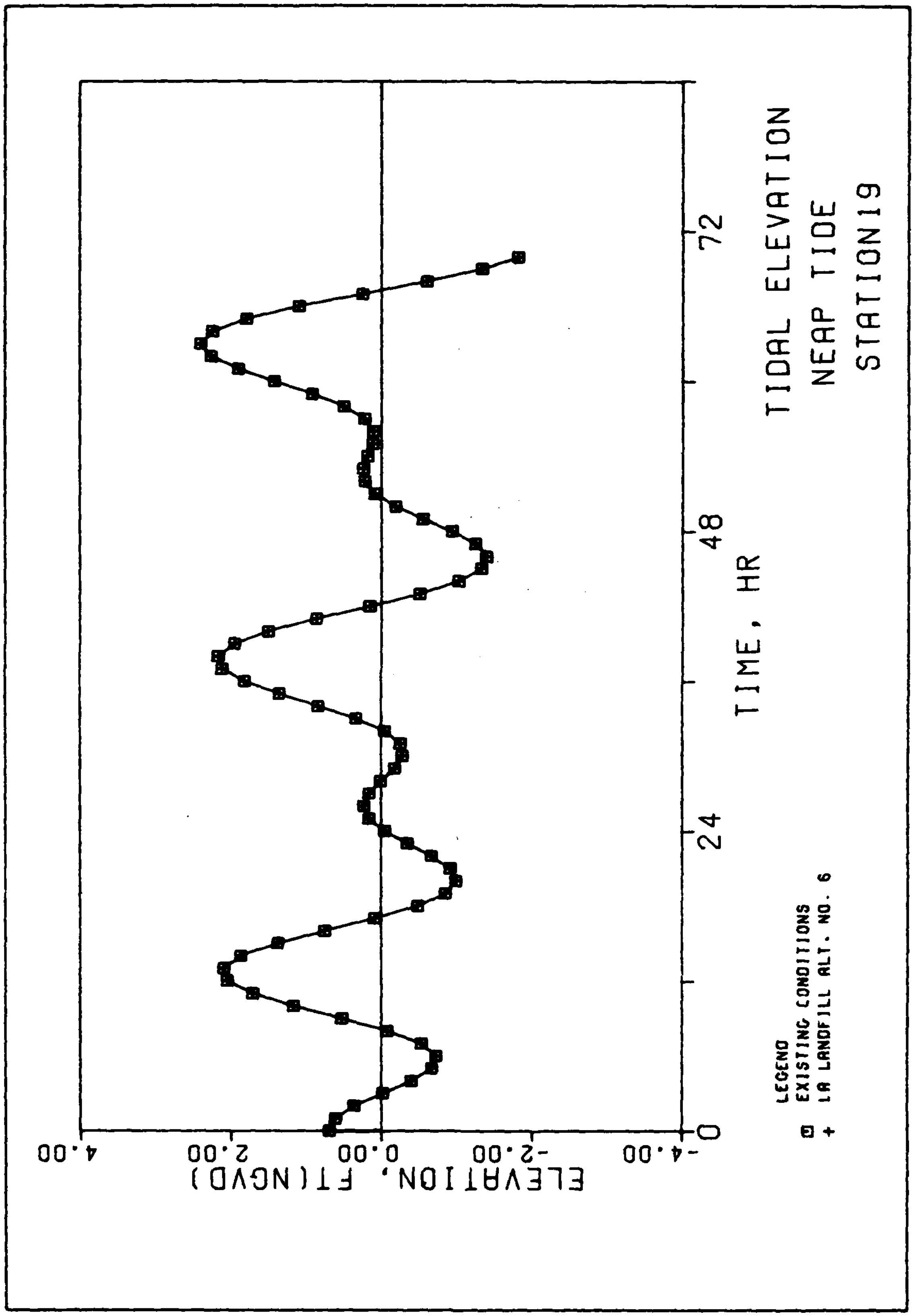

TIDAL ELEVATION
SPRING TIDE
STATION19
TIME, HR
ELEVATION, FT(NGVD)
4.00
2.00
0.00
-2.00
-4.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 21



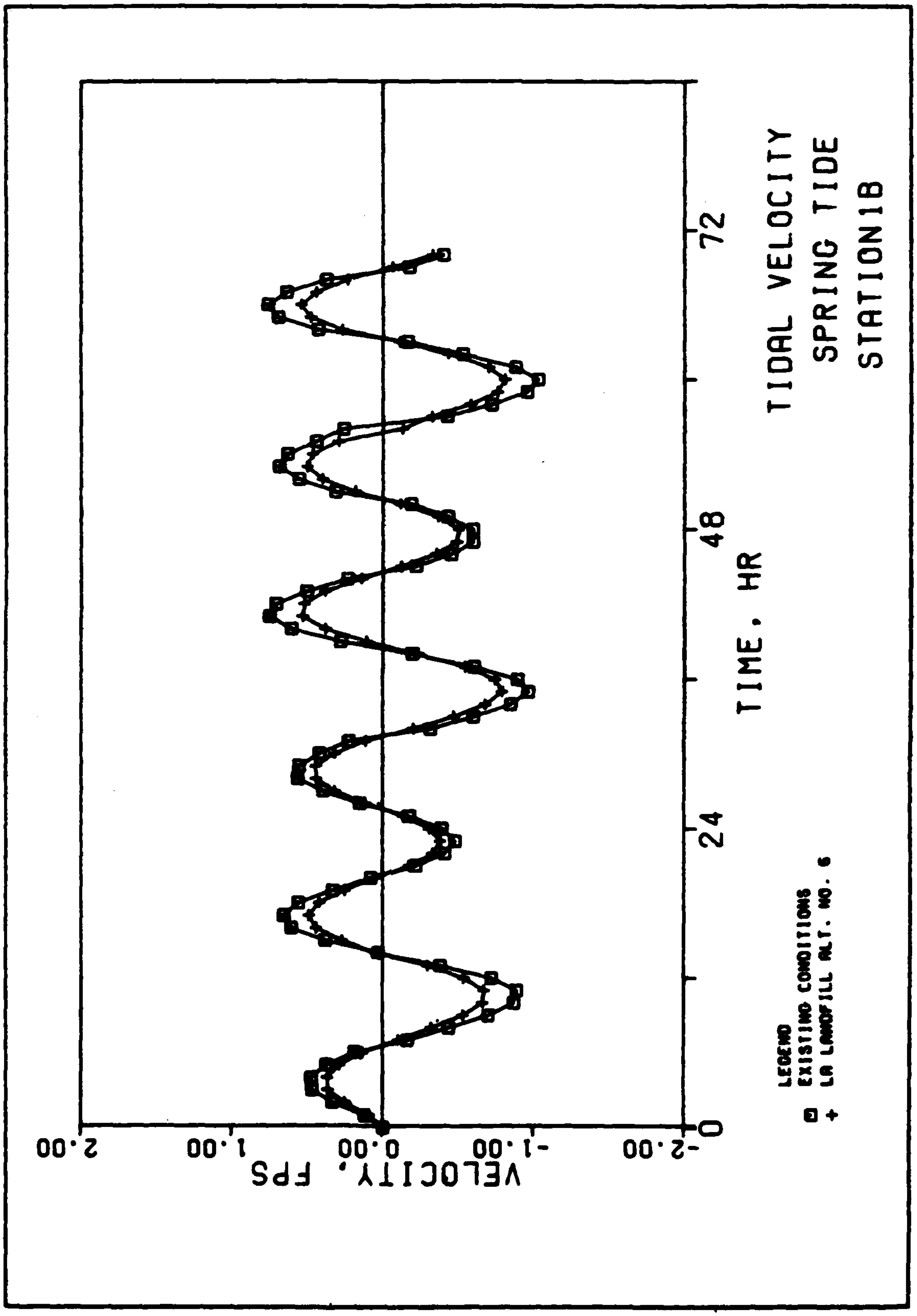
TIDAL ELEVATION
MEAN TIDE
STATION19
TIME, HR
ELEVATION, FT(NGVD)
4.00
2.00
0.00
-2.00
-4.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 22



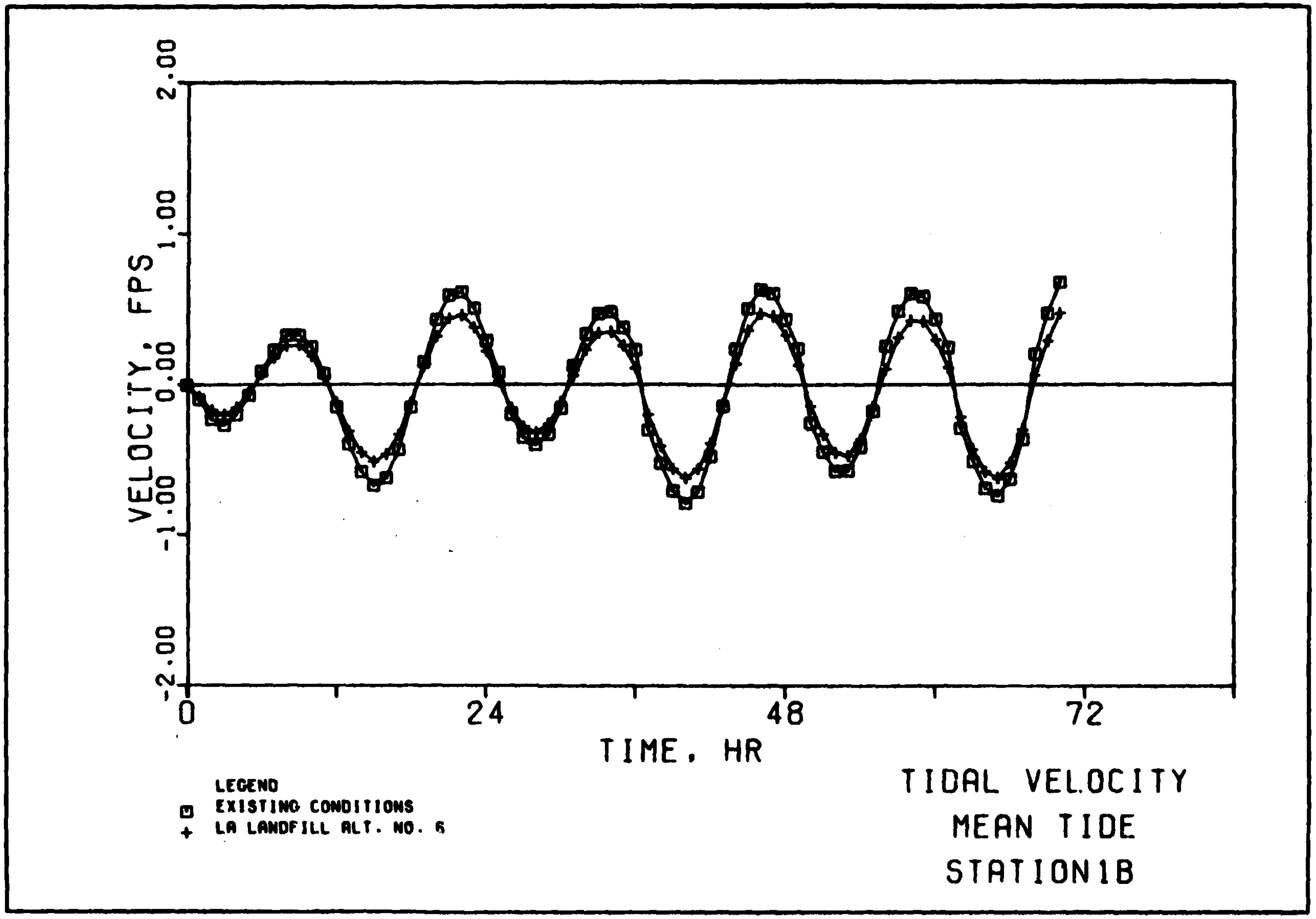
TIDAL ELEVATION
NEAP TIDE
STATION19
TIME, HR
ELEVATION, FT(NGVD)
4.00
2.00
0.00
-2.00
-4.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
1A LANDFILL ALT. NO. 6

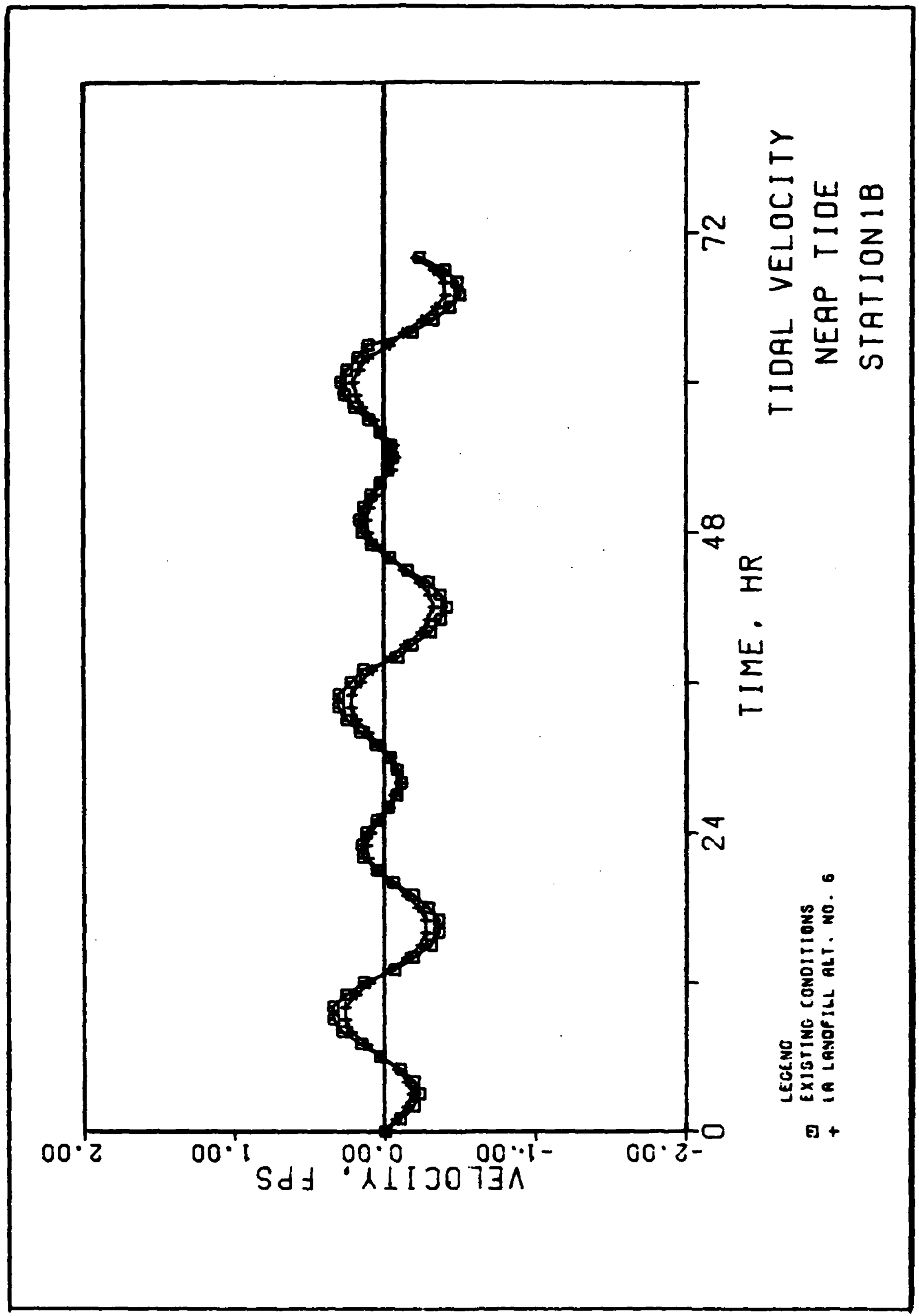
PLATE 23



TIDAL VELOCITY
SPRING TIDE
STATION1B
TIME, HR
VELOCITY, FPS
0
24
48
72
2.00
1.00
0.00
-1.00
-2.00
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

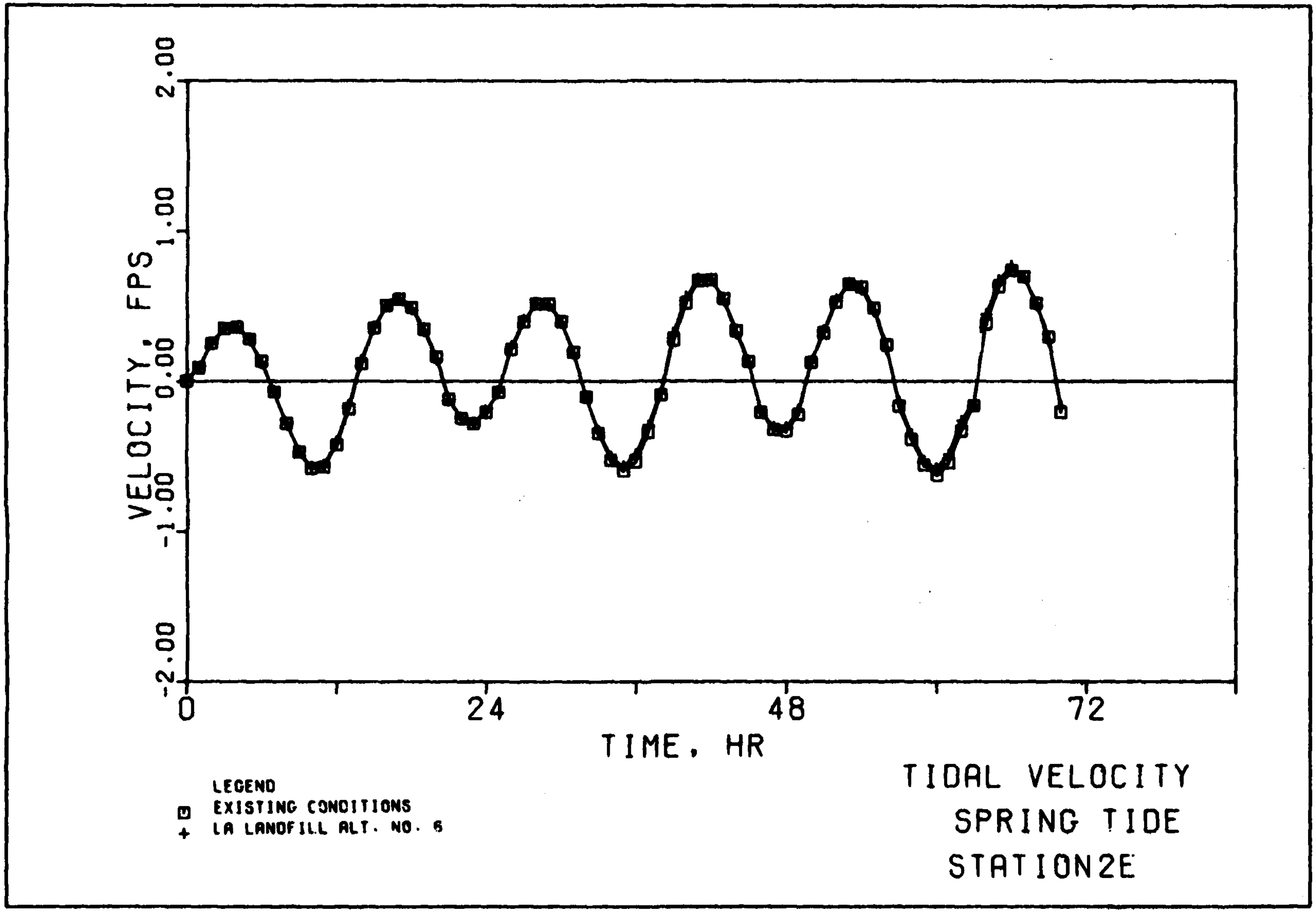
PLATE 24


2.00
1.00
0.00
-1.00
-2.00
VELOCITY, FPS
0
24
48
72
TIME, HR
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6
TIDAL VELOCITY
MEAN TIDE
STATION1B



TIDAL VELOCITY
NEAP TIDE
STATION1B
VELOCITY, FPS
2.00
1.00
0.00
-1.00
-2.00
TIME, HR
0
24
48
72
LEGEND
EXISTING CONDITIONS
IA LANDFILL ALT. NO. 6

PLATE 26



VELOCITY, FPS
2.00
1.00
0.00
-1.00
-2.00
0
24
48
72
TIME, HR
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6
TIDAL VELOCITY
SPRING TIDE
STATION2E

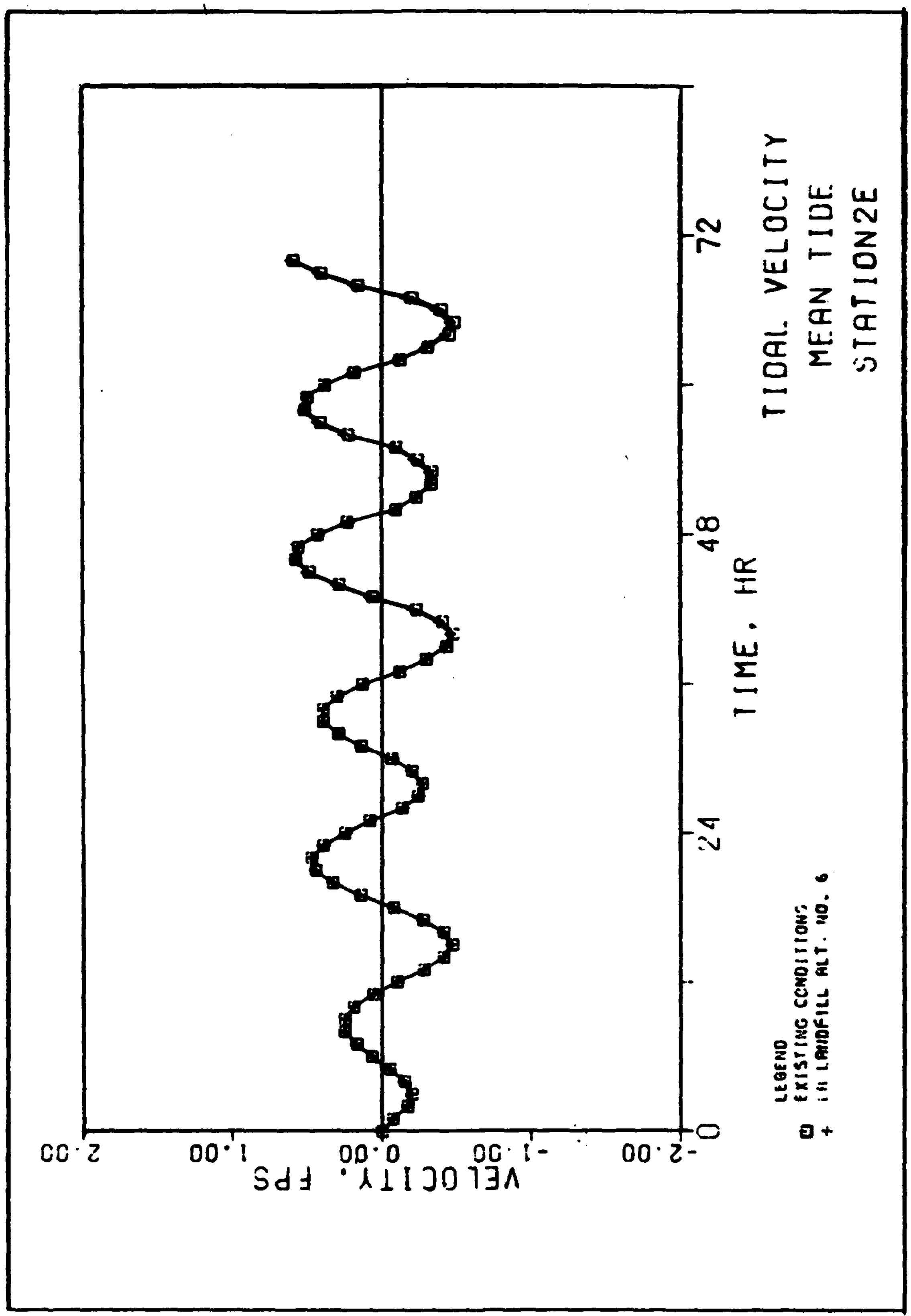
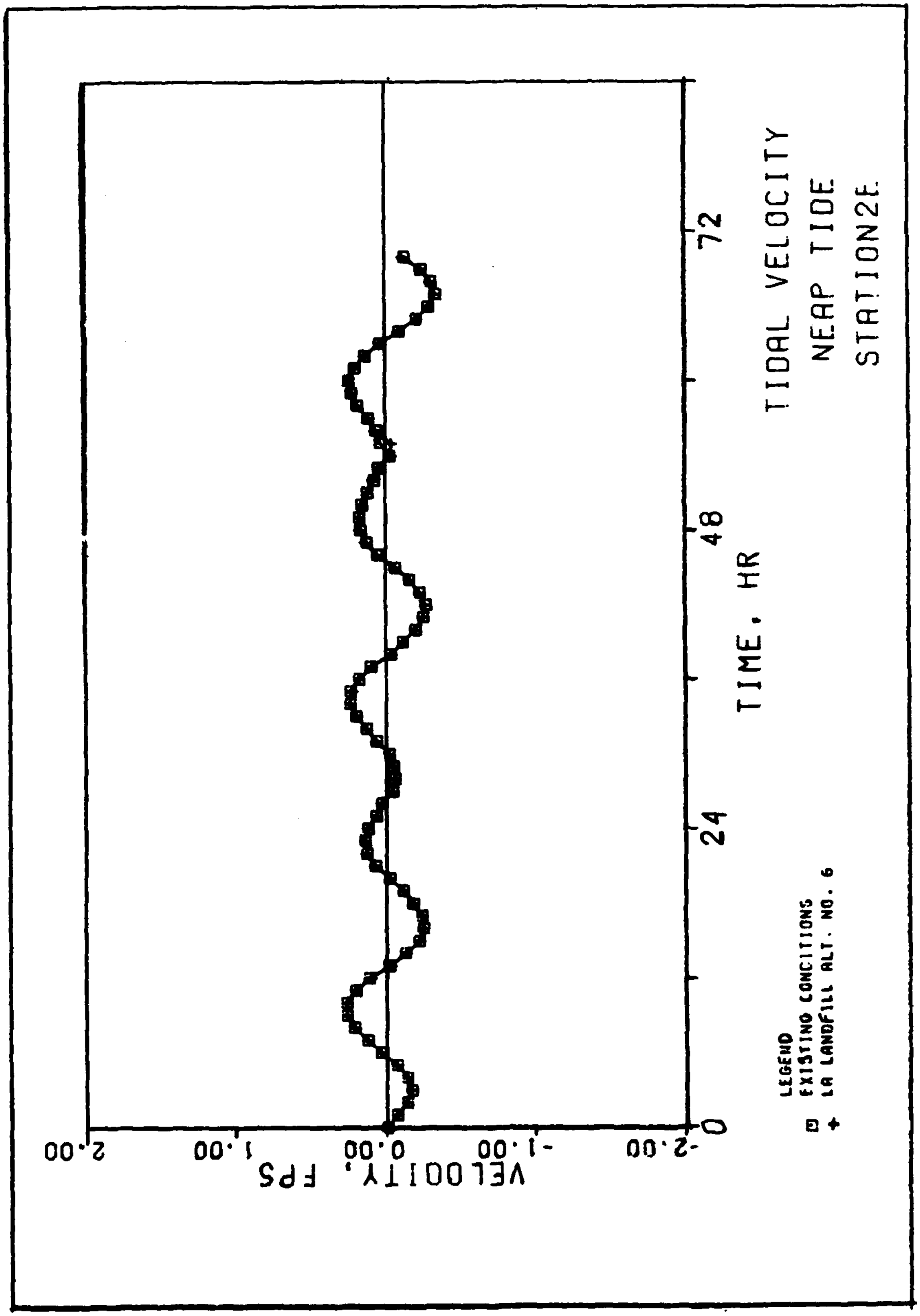
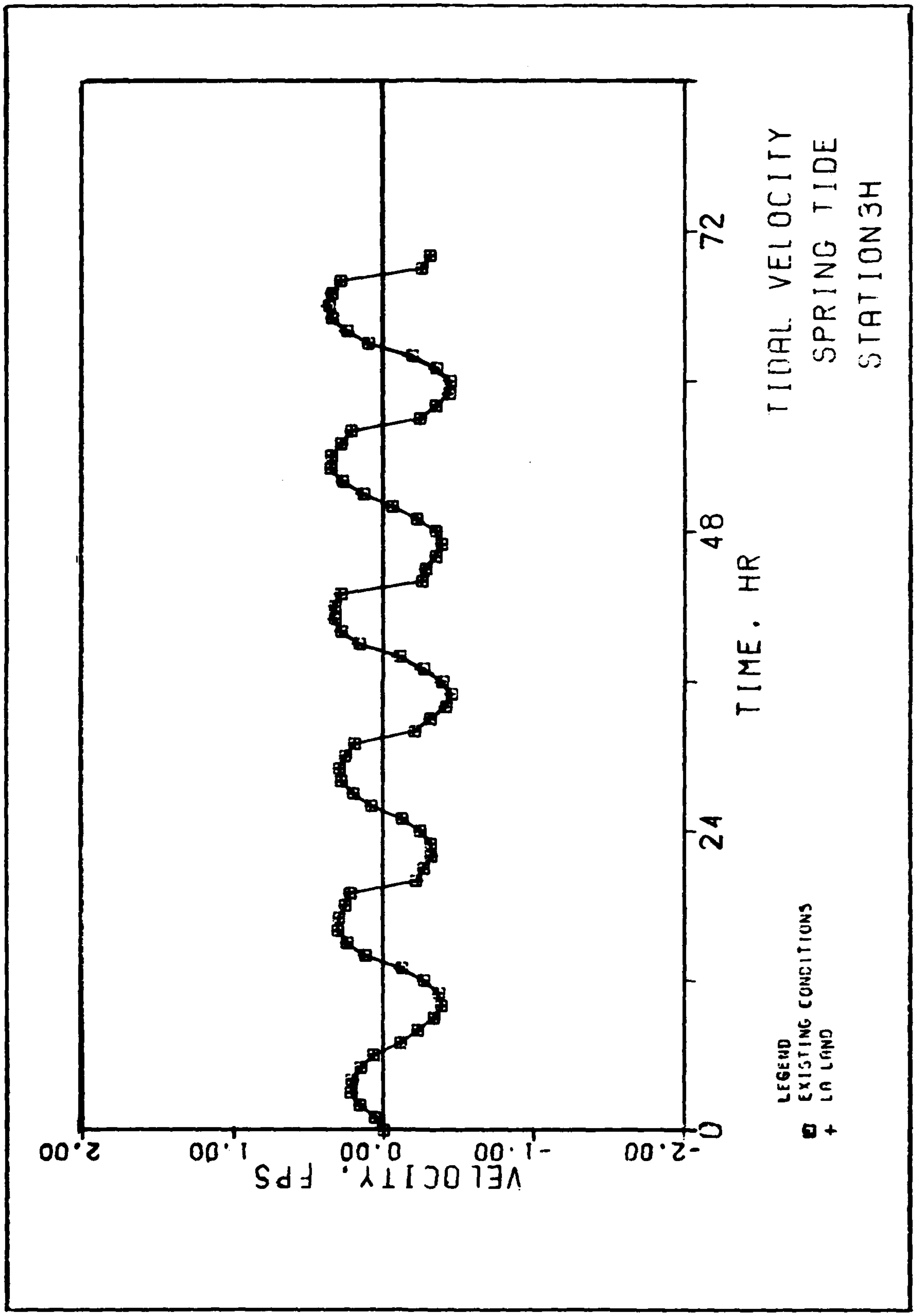

TIDAL VELOCITY
MEAN TIDE
STATION2E
TIME, HR
0
24
48
72
VELOCITY, FPS
-2.00
-1.00
0.00
1.00
2.00
LEGEND
EXISTING CONDITIONS
LANDFILL ALT. NO. 6

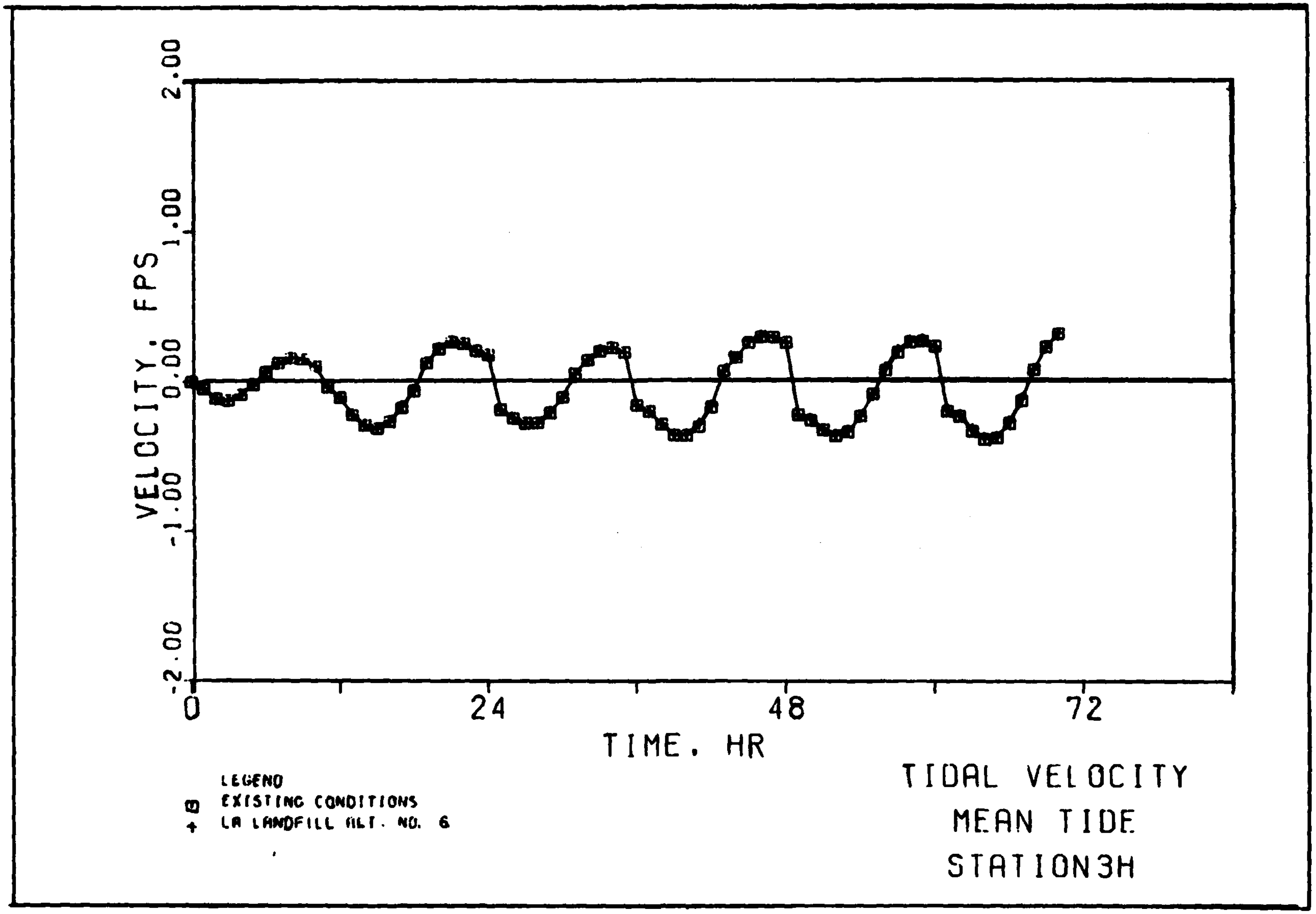
PLATE 28


TIDAL VELOCITY
NEAP TIDE
STATION2E
TIME, HR
VELOCITY, FPS
2.00
1.00
0.00
-1.00
-2.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6



TIDAL VELOCITY
SPRING TIDE
STATION3H
TIME, HR
0
24
48
72
VELOCITY, FPS
2.00
1.00
0.00
-1.00
-2.00
LEGEND
EXISTING CONDITIONS
LA LAND

PLATE 30


2.00
1.00
0.00
-1.00
-2.00
VELOCITY, FPS
0
24
48
72
TIME, HR
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6
TIDAL VELOCITY
MEAN TIDE
STATION3H

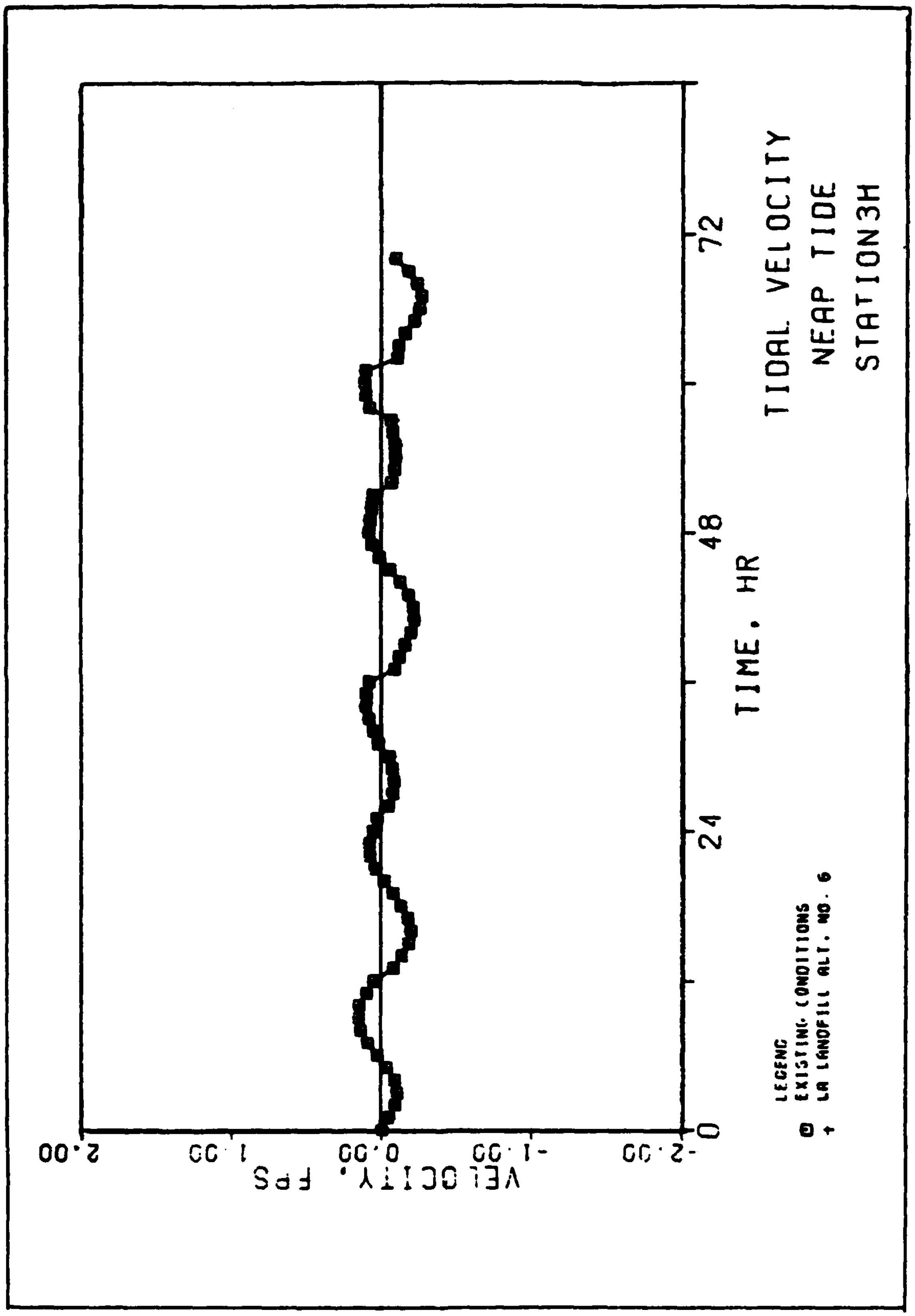

TIDAL VELOCITY
NEAP TIDE
STATION3H
VELOCITY, FPS
TIME, HR
2.00
1.00
0.00
-1.00
-2.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 32

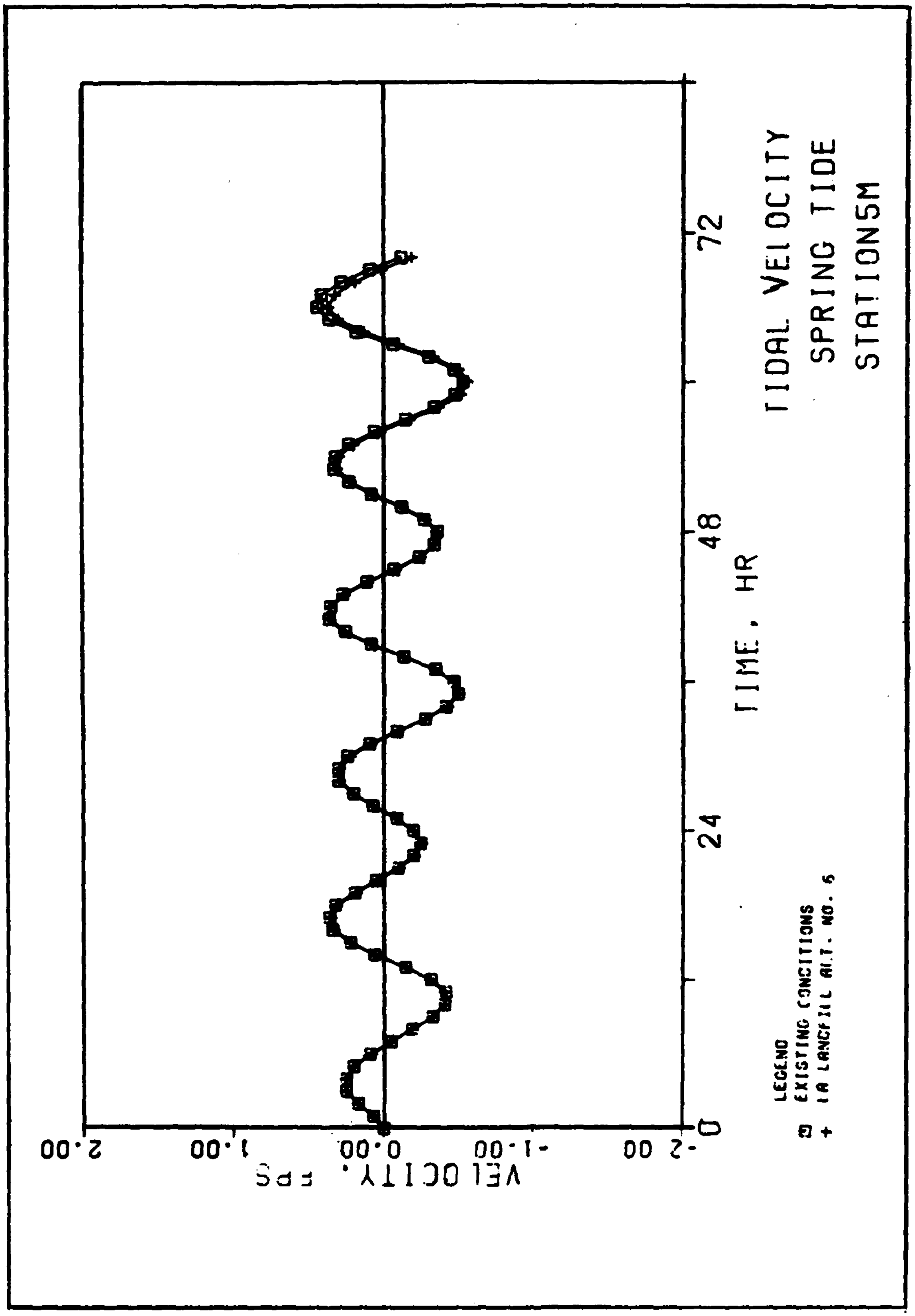

TIDAL VELOCITY
SPRING TIDE
STATION5M
TIME, HR
0
24
48
72
VELOCITY, FPS
-2.00
-1.00
0.00
1.00
2.00
LEGEND
EXISTING CONDITIONS
1A LANDFILL ALT. NO. 6

PLATE 33

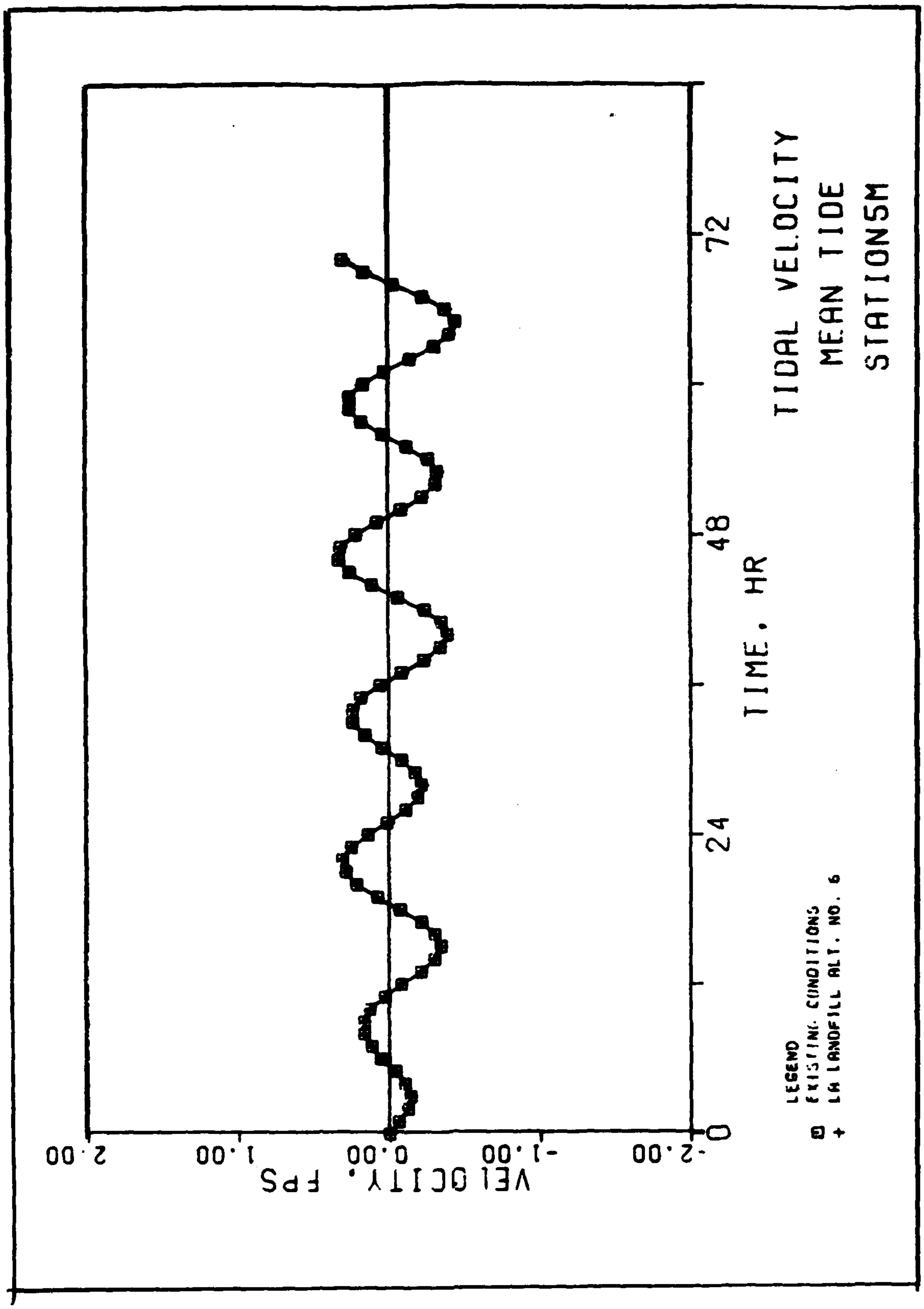

TIDAL VELOCITY
MEAN TIDE
STATION5M
TIME, HR
VELOCITY, FPS
0
24
48
72
2.00
1.00
0.00
-1.00
-2.00
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 34

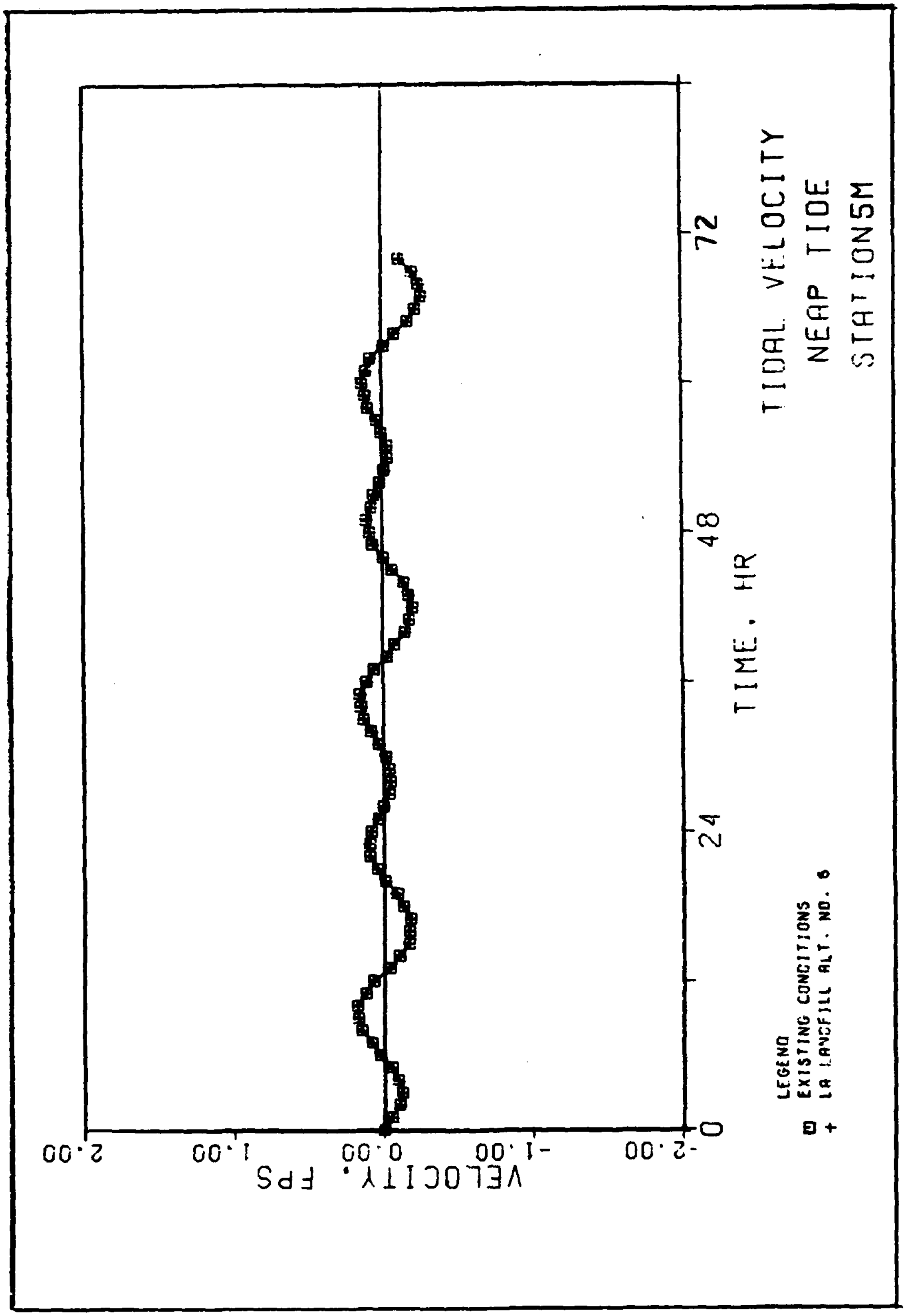

TIDAL VELOCITY
NEAP TIDE
STATION5M
TIME, HR
0
24
48
72
VELOCITY, FPS
2.00
1.00
0.00
-1.00
-2.00
LEGEND
EXISTING CONDITIONS
+ LA LANDFILL ALT. NO. 6

PLATE 35

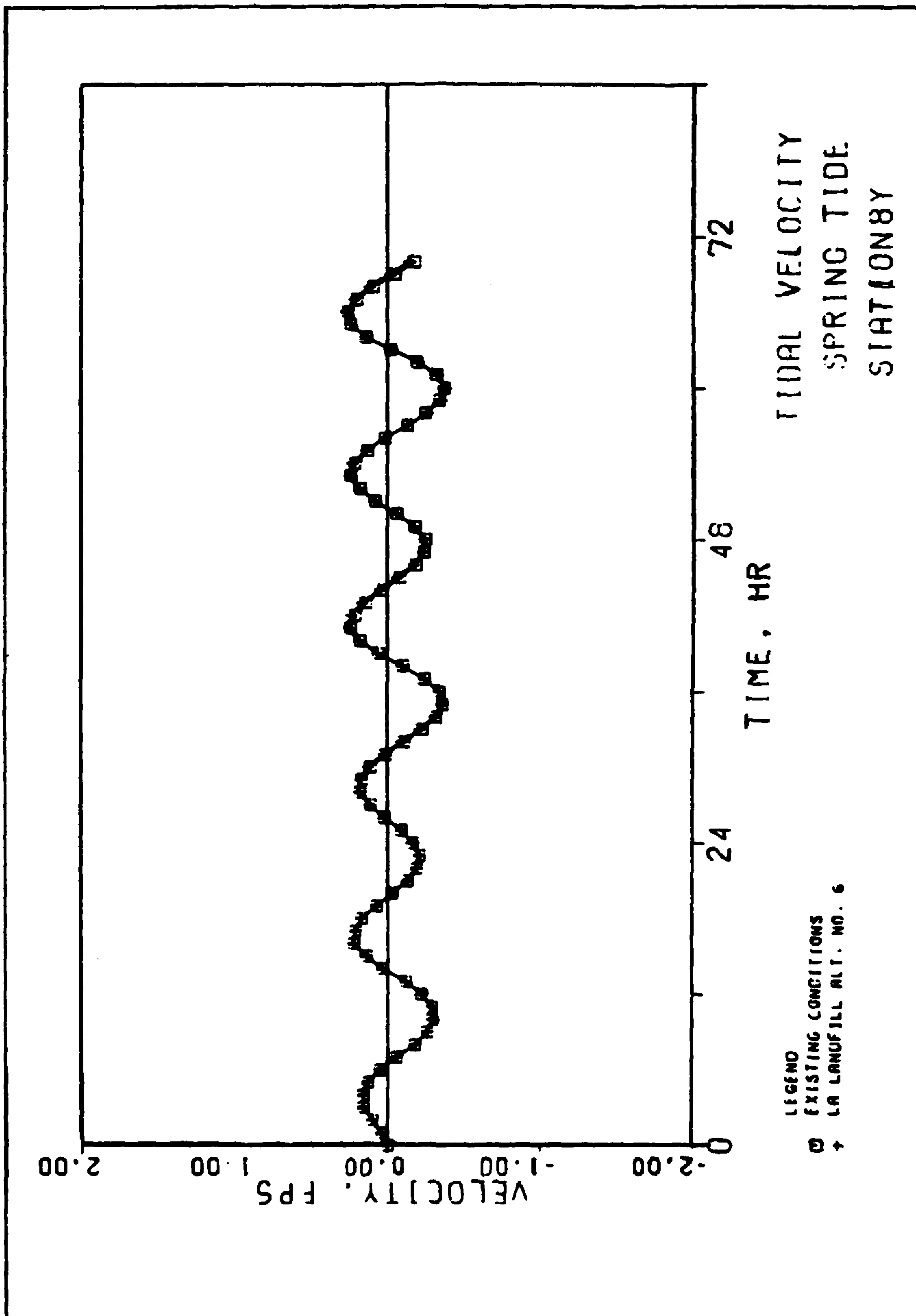

TIDAL VELOCITY
SPRING TIDE
STATION8Y
TIME, HR
VELOCITY, FPS
0
24
48
72
-2.00
-1.00
0.00
1.00
2.00
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 36

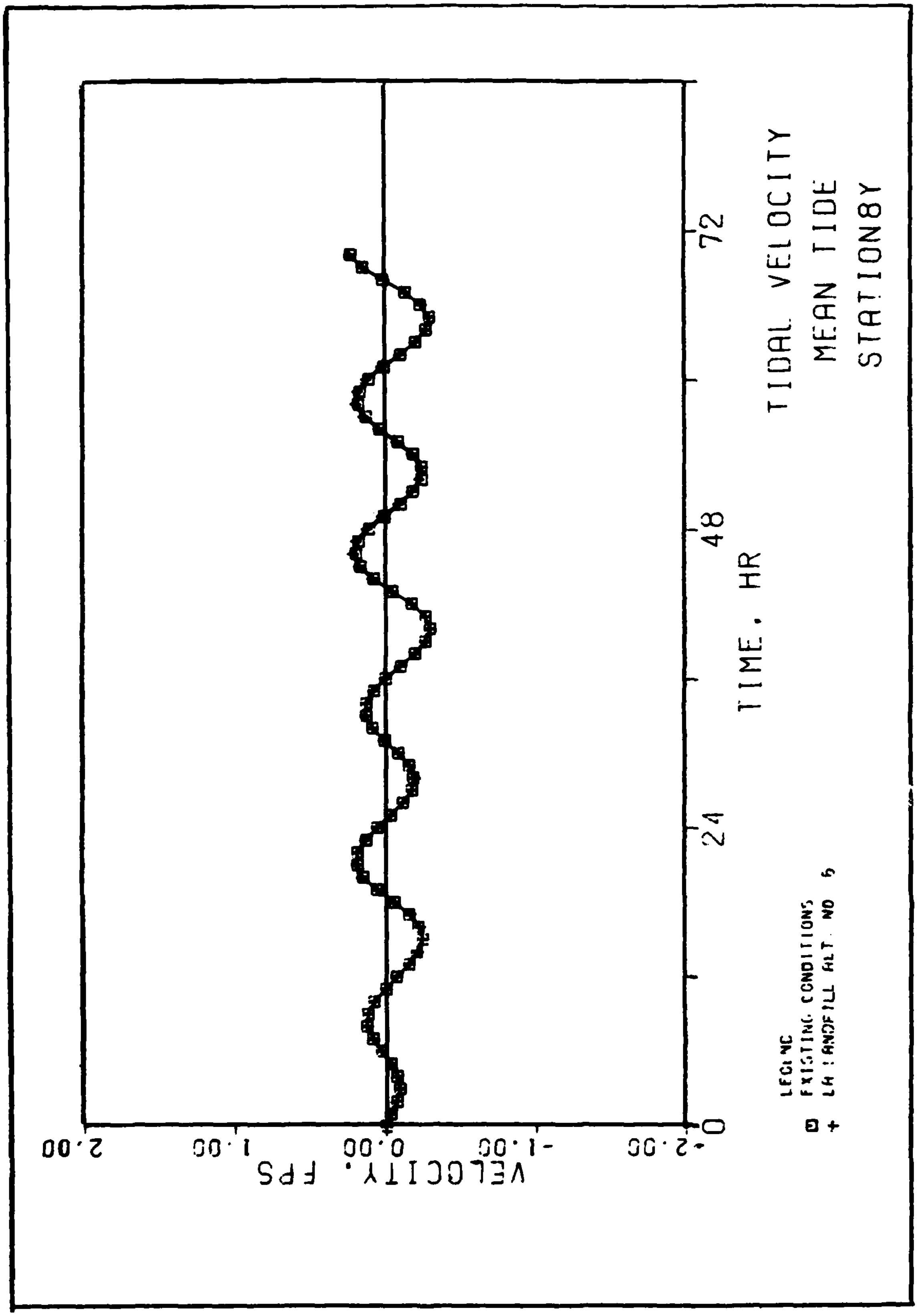

TIDAL VELOCITY
MEAN TIDE
STATION8Y
TIME, HR
VELOCITY, FPS
0
24
48
72
-2.00
-1.00
0.00
1.00
2.00
LEGEND
EXISTING CONDITIONS
LANDFILL ALT. NO 6

PLATE 37

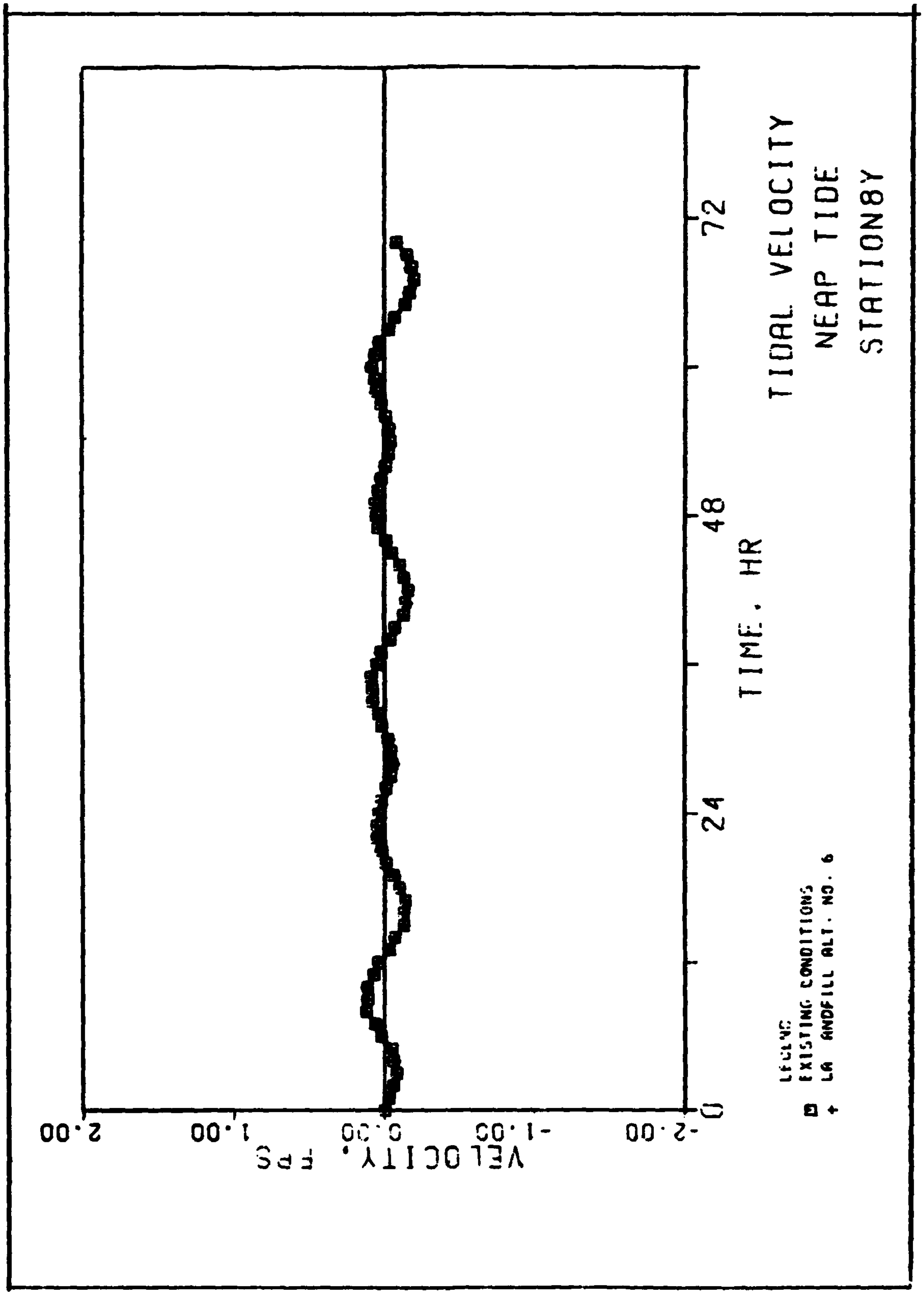
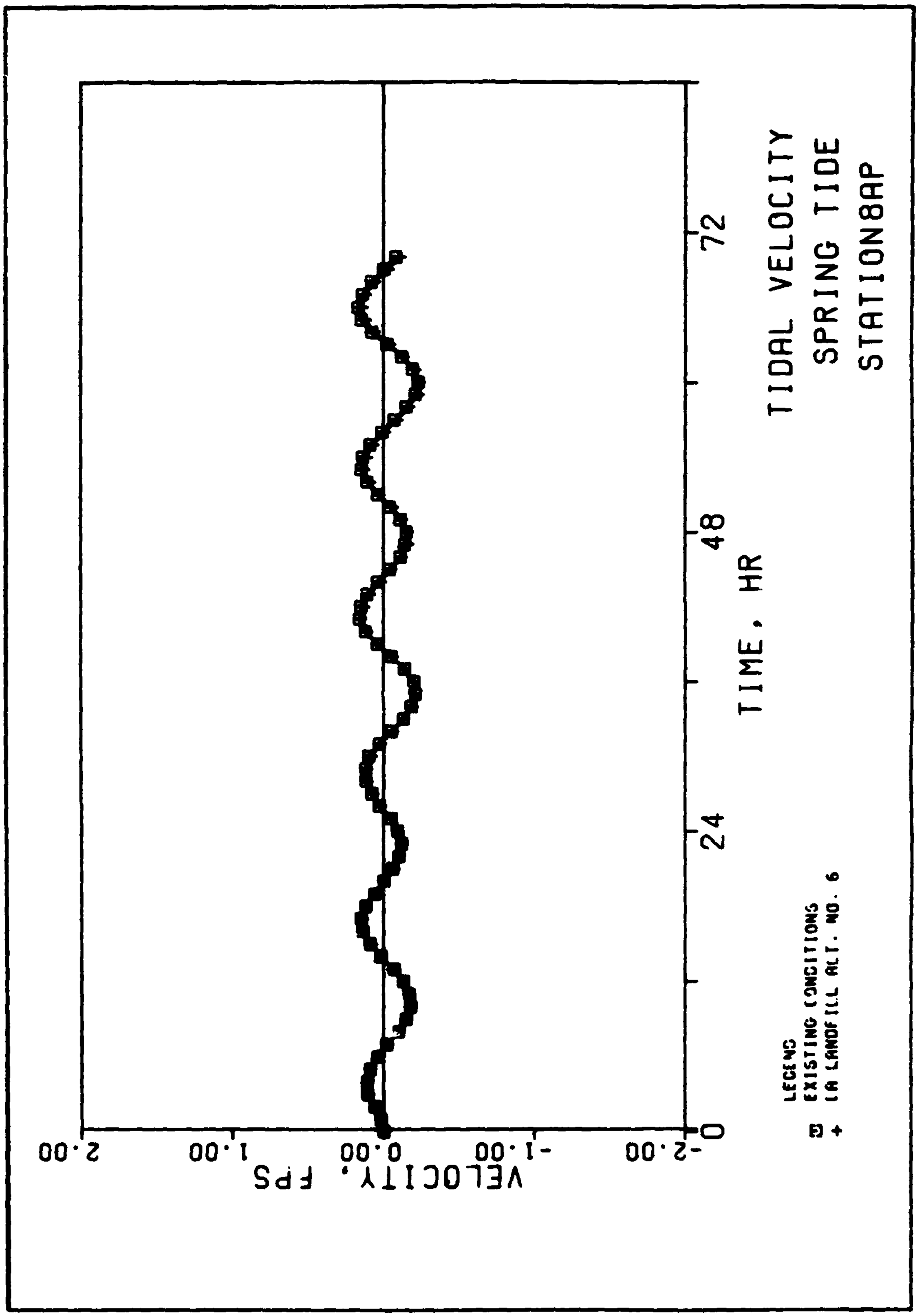

TIDAL VELOCITY
NEAP TIDE
STATION8Y
TIME, HR
0
24
48
72
VELOCITY, FPS
2.00
1.00
0.00
-1.00
-2.00
LEGEND
EXISTING CONDITIONS
LANDFILL ALT. NO. 6

PLATE 38



VELOCITY, FPS
2.00
1.00
0.00
-1.00
-2.00
0
24
48
72
TIME, HR
LEGEND
EXISTING CONDITIONS
1A LANDFILL ALT. NO. 6
TIDAL VELOCITY
SPRING TIDE
STATION8AP

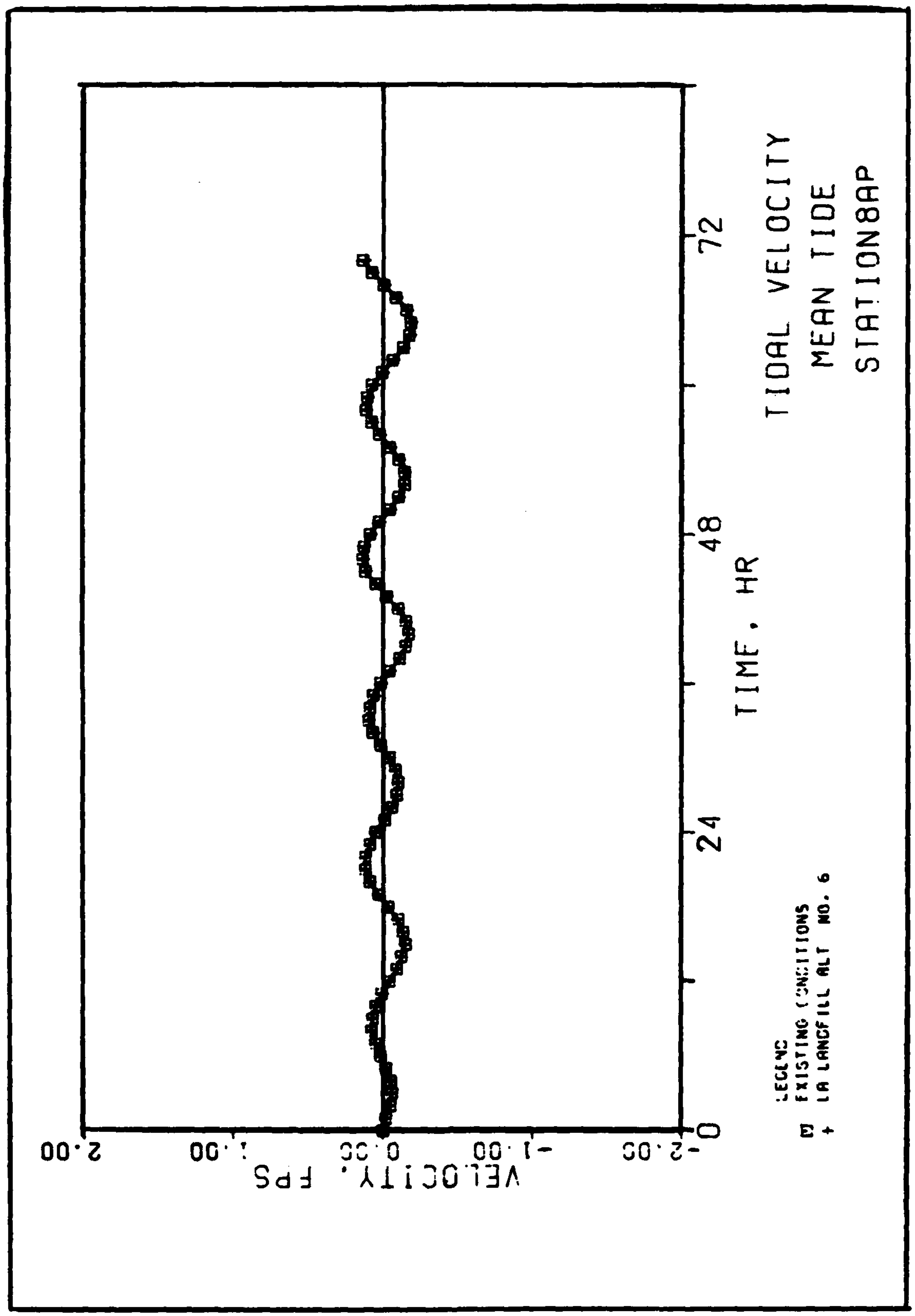

TIDAL VELOCITY
MEAN TIDE
STATION8AP
TIME, HR
0
24
48
72
VELOCITY, FPS
2.00
1.00
0.00
-1.00
-2.00
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT NO. 6

PLATE 40

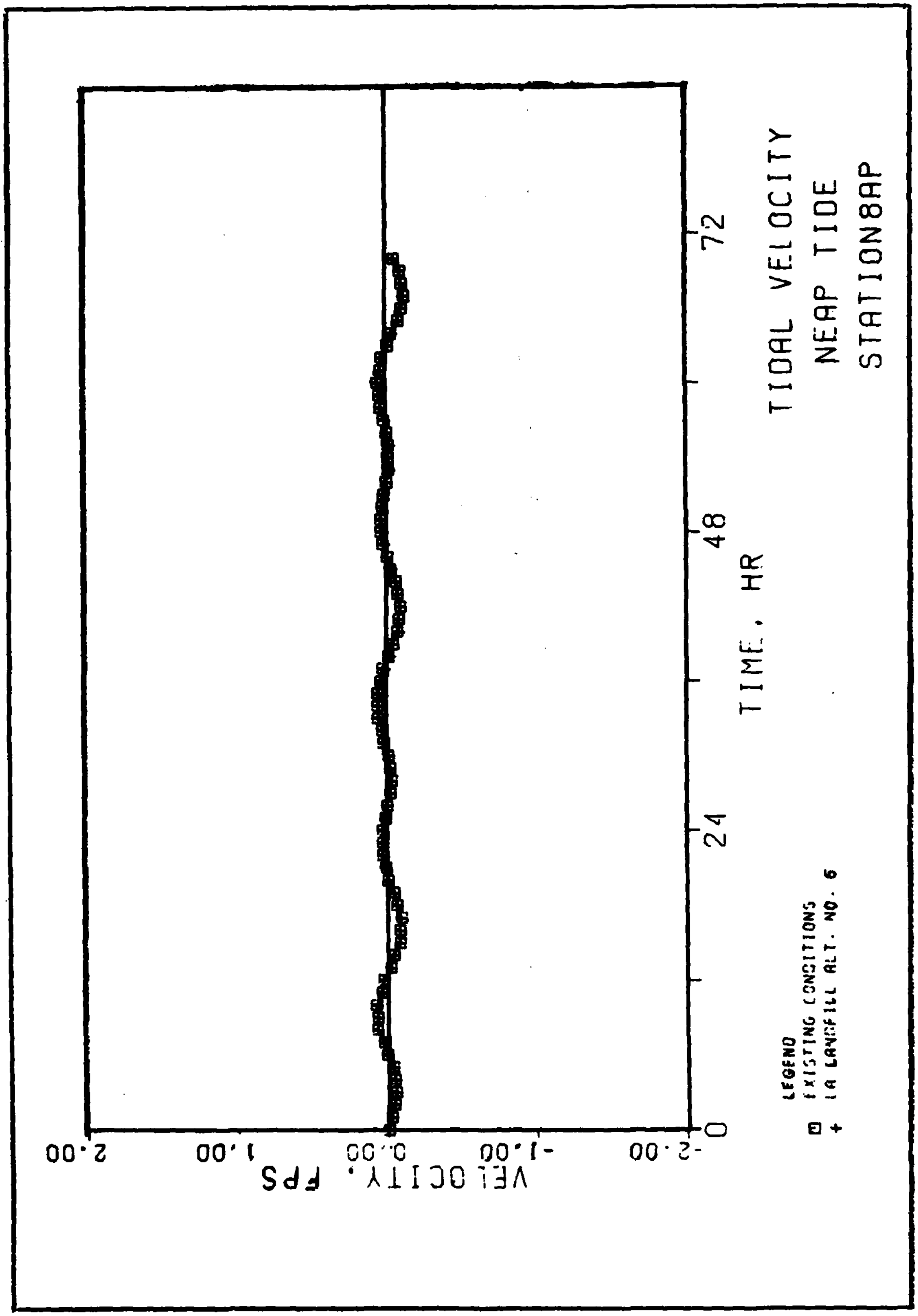

TIDAL VELOCITY
NEAP TIDE
STATION8AP
TIME, HR
VELOCITY, FPS
2.00
1.00
0.00
-1.00
-2.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
1A LANDFILL ALT. NO. 6

PLATE 41

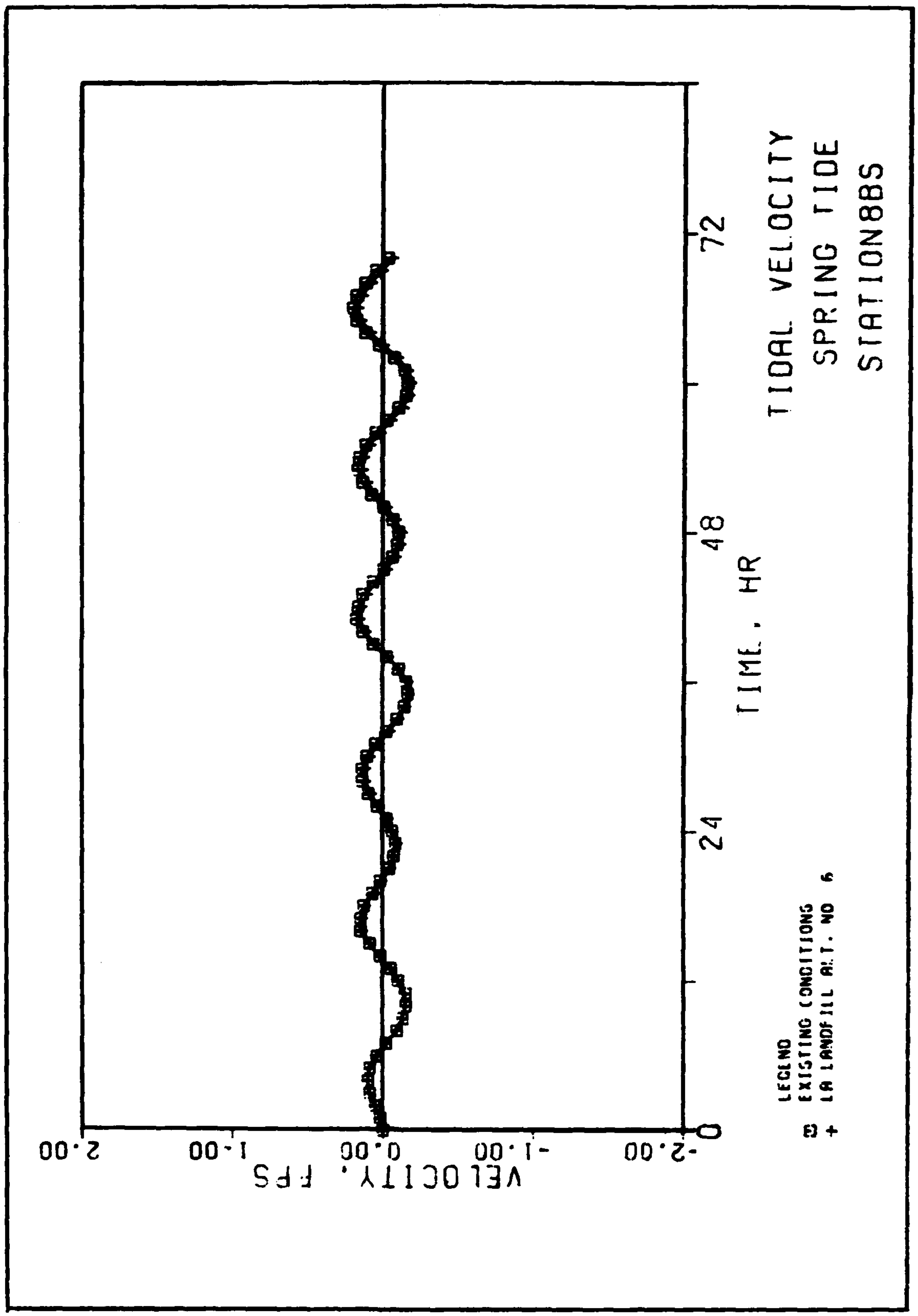
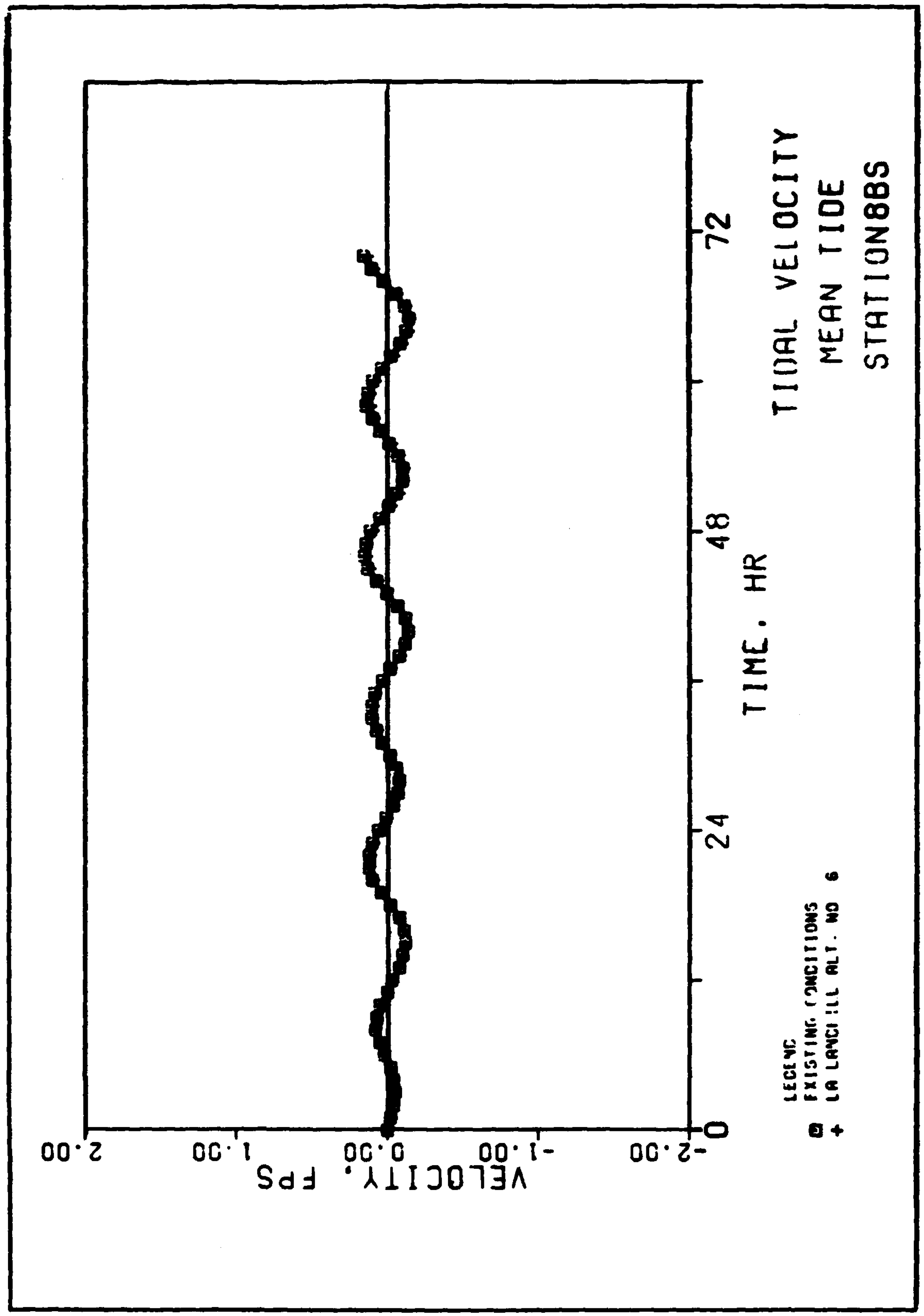
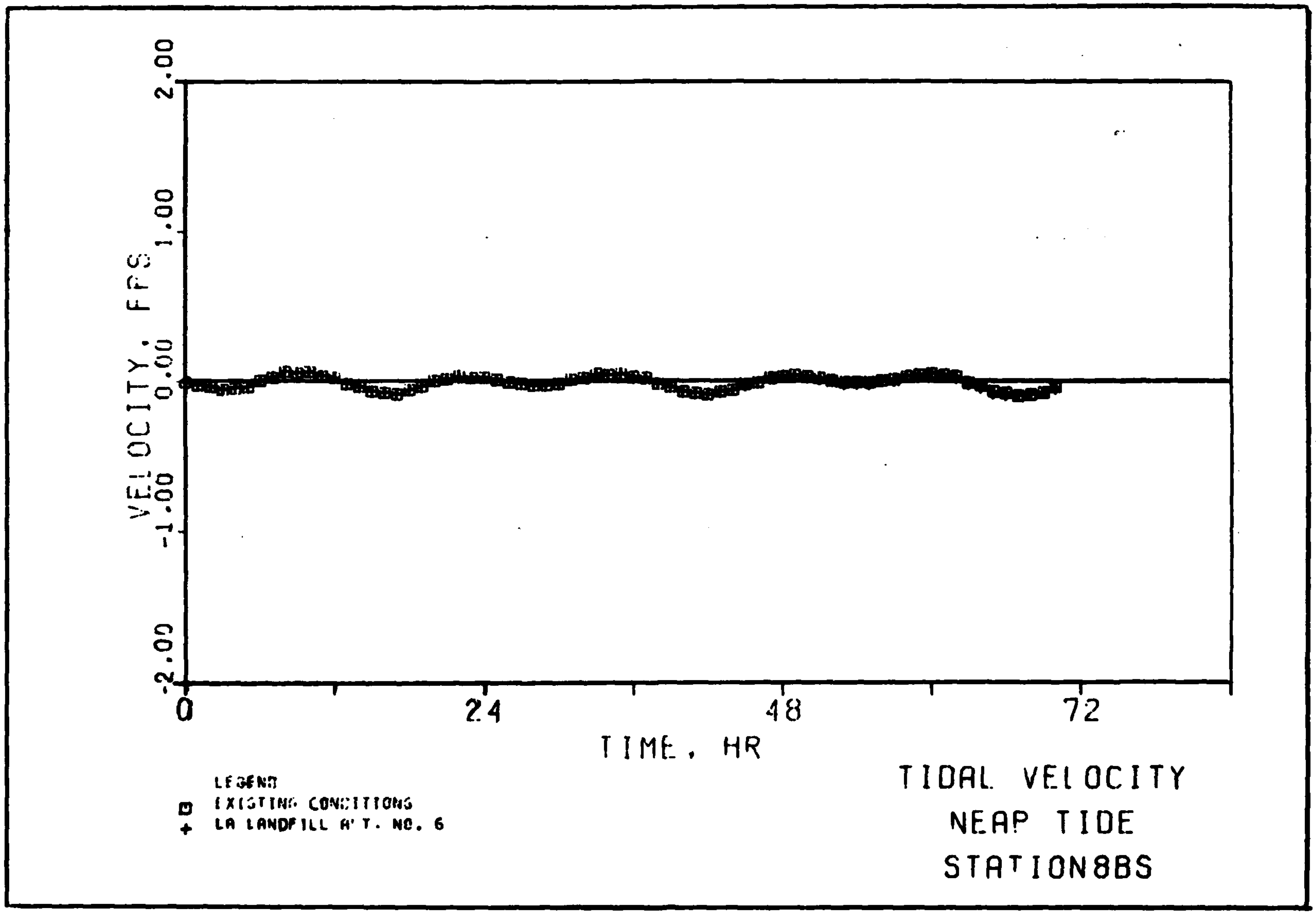

TIDAL VELOCITY
SPRING TIDE
STATION8BS
TIME, HR
VELOCITY, FPS
0
24
48
72
2.00
1.00
0.00
-1.00
-2.00
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO 6

PLATE 42



TIDAL VELOCITY
MEAN TIDE
STATION8BS
TIME, HR
0
24
48
72
VELOCITY, FPS
2.00
1.00
0.00
-1.00
-2.00
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO 6

PLATE 43


2.00
1.00
0.00
-1.00
-2.00
VELOCITY, FPS
0
24
48
72
TIME, HR
LEGEND
EXISTING CONDITIONS
LA LANDFILL A'T. NO. 6
TIDAL VELOCITY
NEAP TIDE
STATION8BS

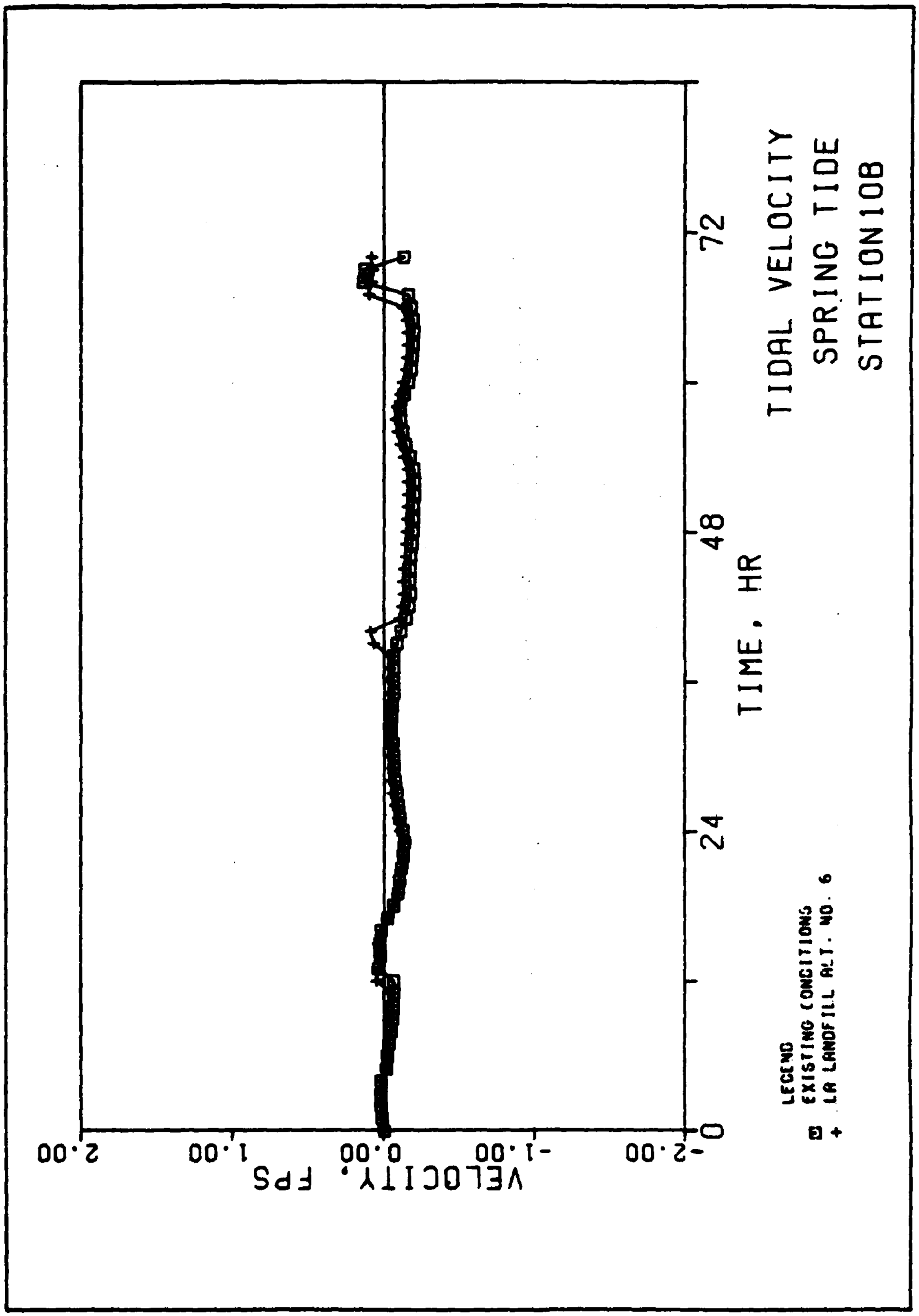

TIDAL VELOCITY
SPRING TIDE
STATION10B
TIME, HR
VELOCITY, FPS
0
24
48
72
2.00
1.00
0.00
-1.00
-2.00
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 45

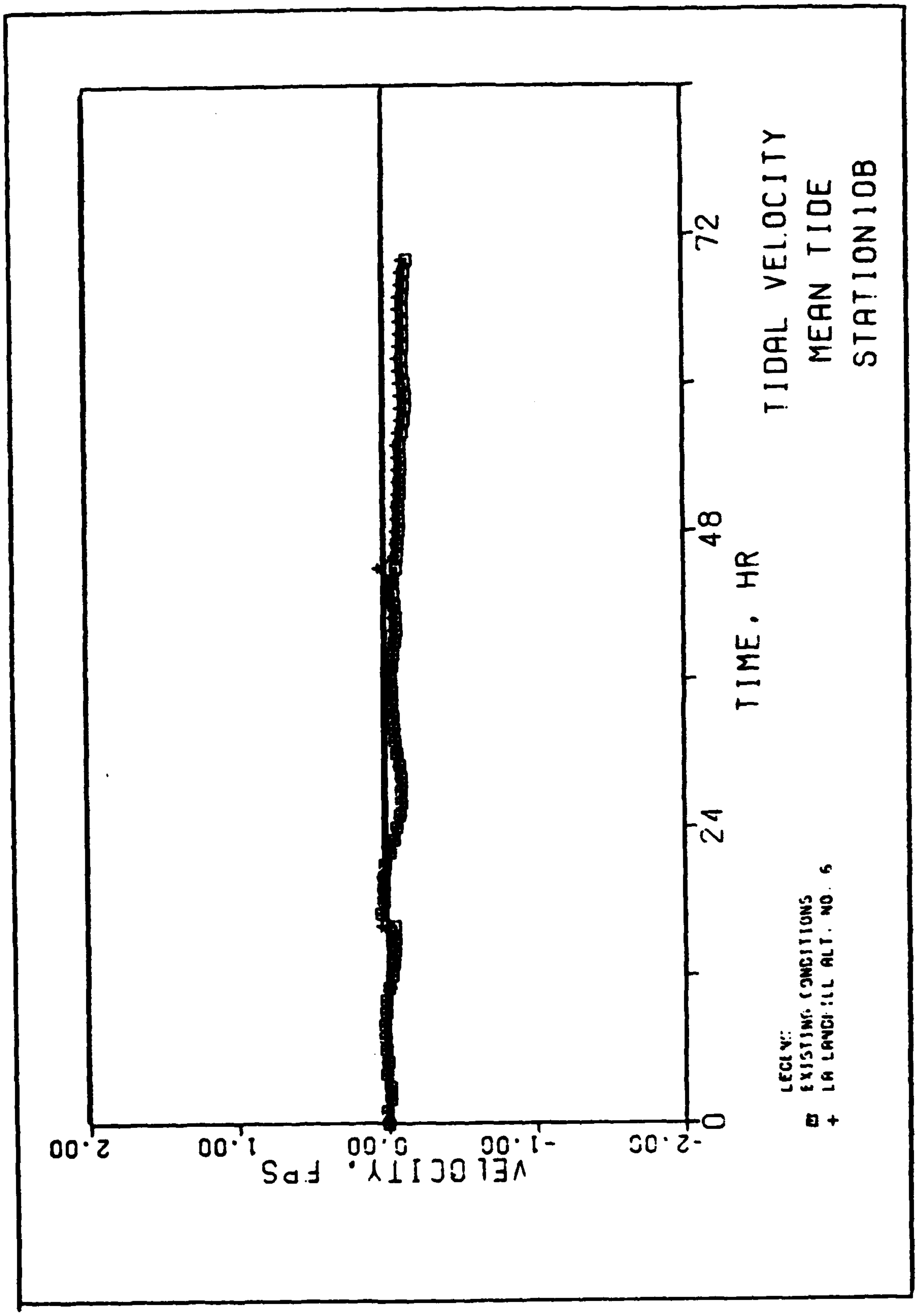

TIDAL VELOCITY
MEAN TIDE
STATION10B
TIME, HR
0
24
48
72
VELOCITY, FPS
2.00
1.00
0.00
-1.00
-2.00
LEGEND:
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 46

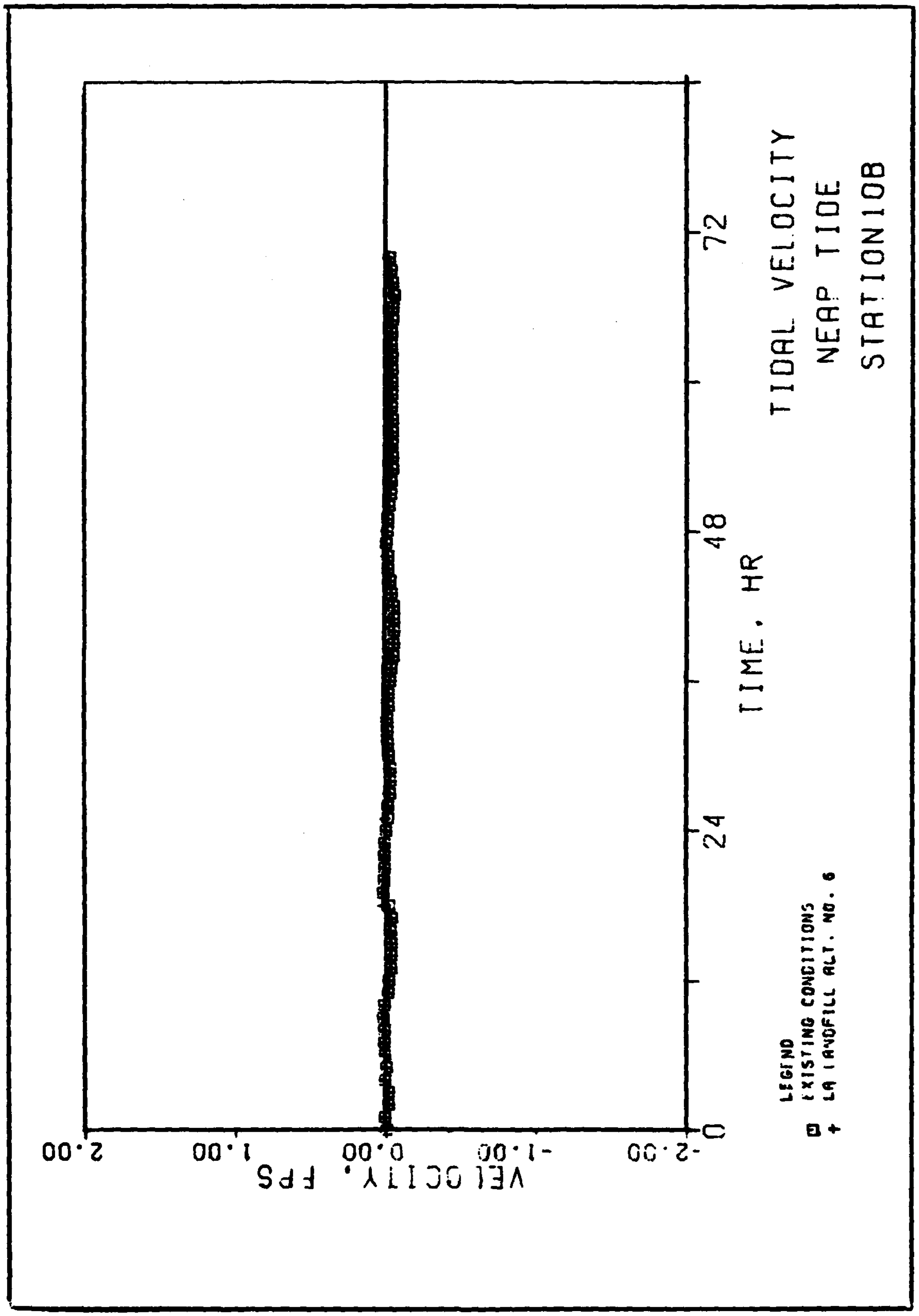

TIDAL VELOCITY
NEAR TIDE
STATION10B
TIME, HR
VELOCITY, FPS
0
24
48
72
2.00
1.00
0.00
-1.00
-2.00
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 47

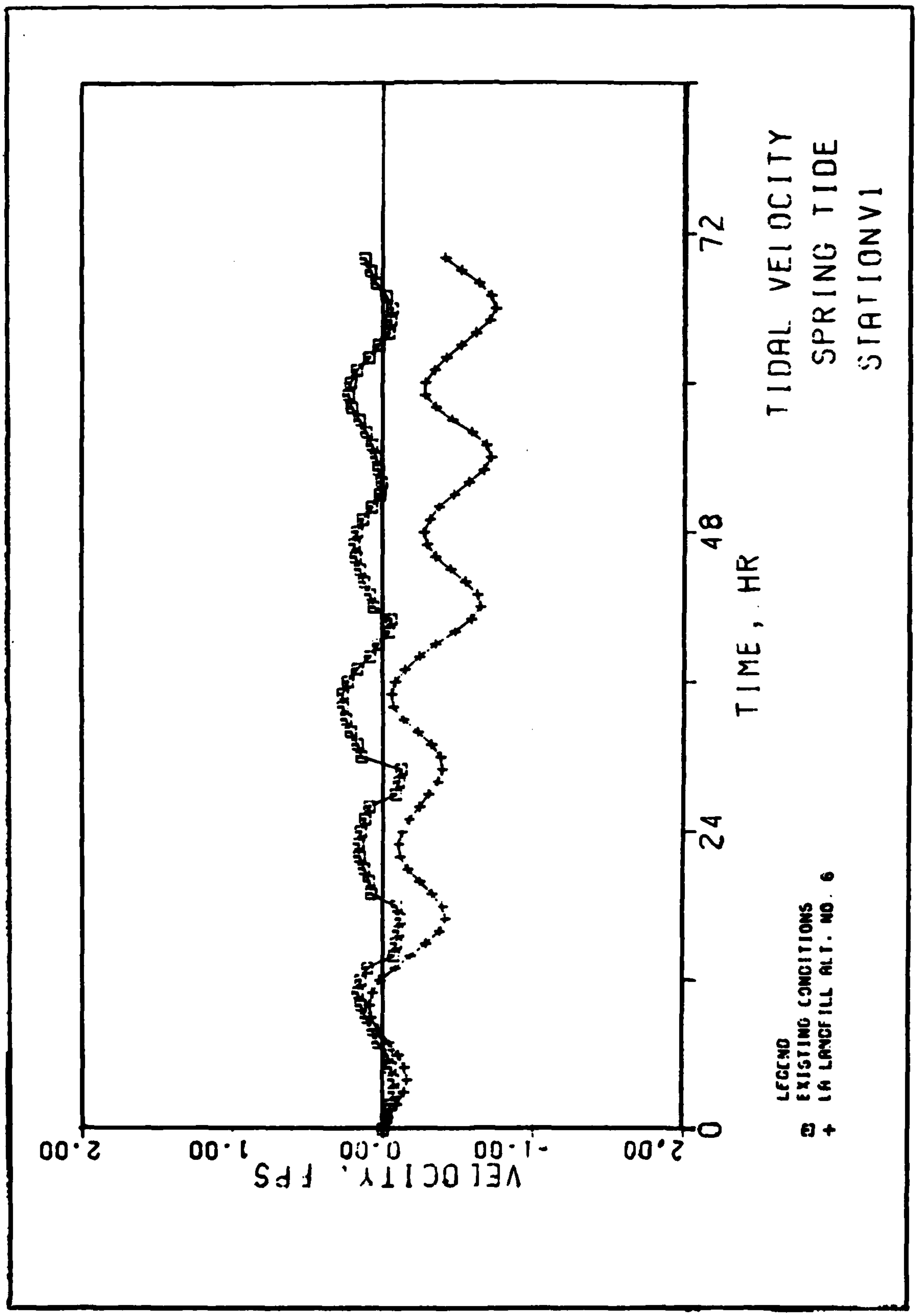
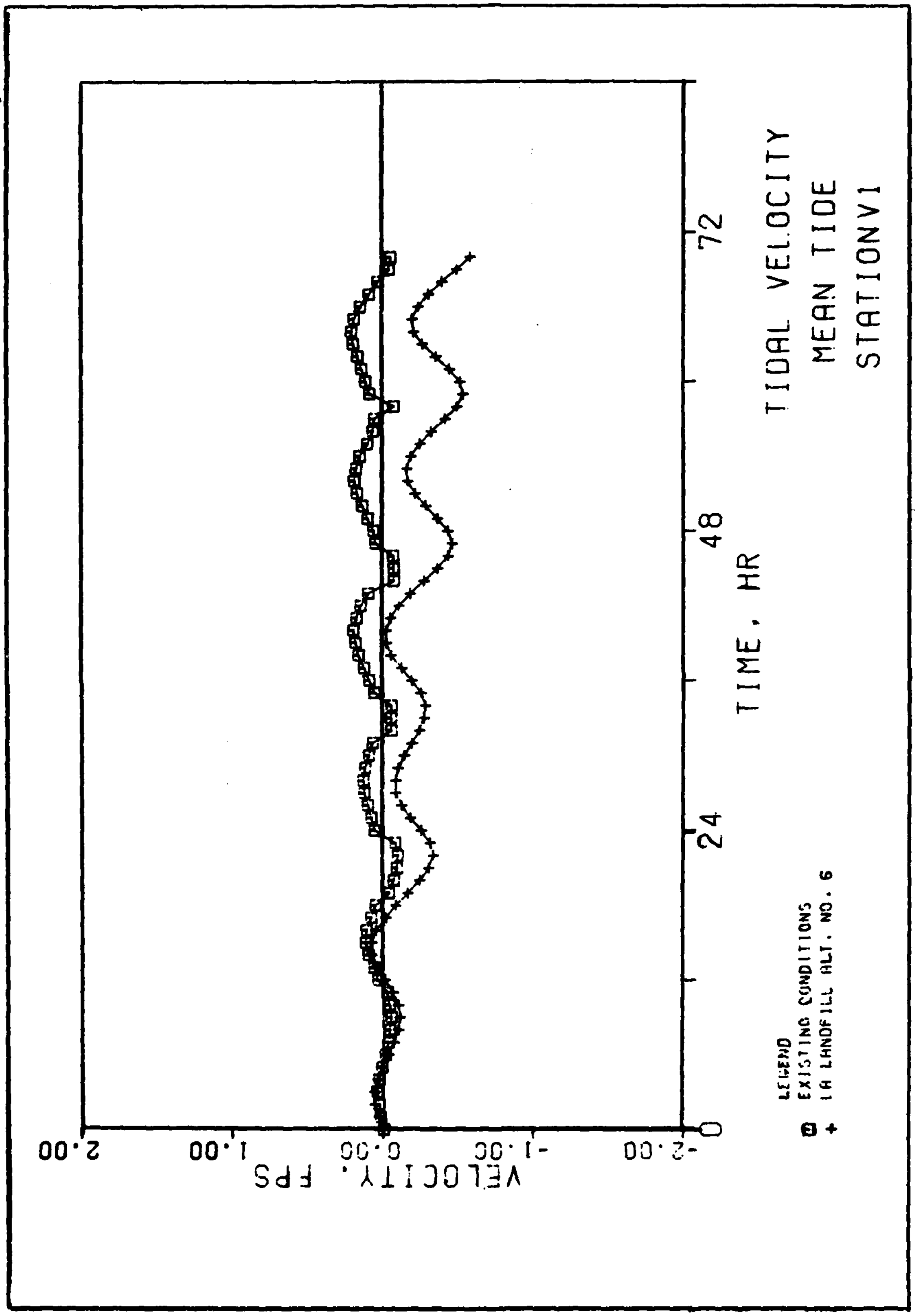

TIDAL VELOCITY
SPRING TIDE
STATIONV1
TIME, HR
VELOCITY, FPS
0
24
48
72
2.00
1.00
0.00
-1.00
-2.00
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 48



TIDAL VELOCITY
MEAN TIDE
STATIONV1
TIME, HR
VELOCITY, FPS
2.00
1.00
0.00
-1.00
-2.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
1A LANDFILL ALT. NO. 6

PLATE 49

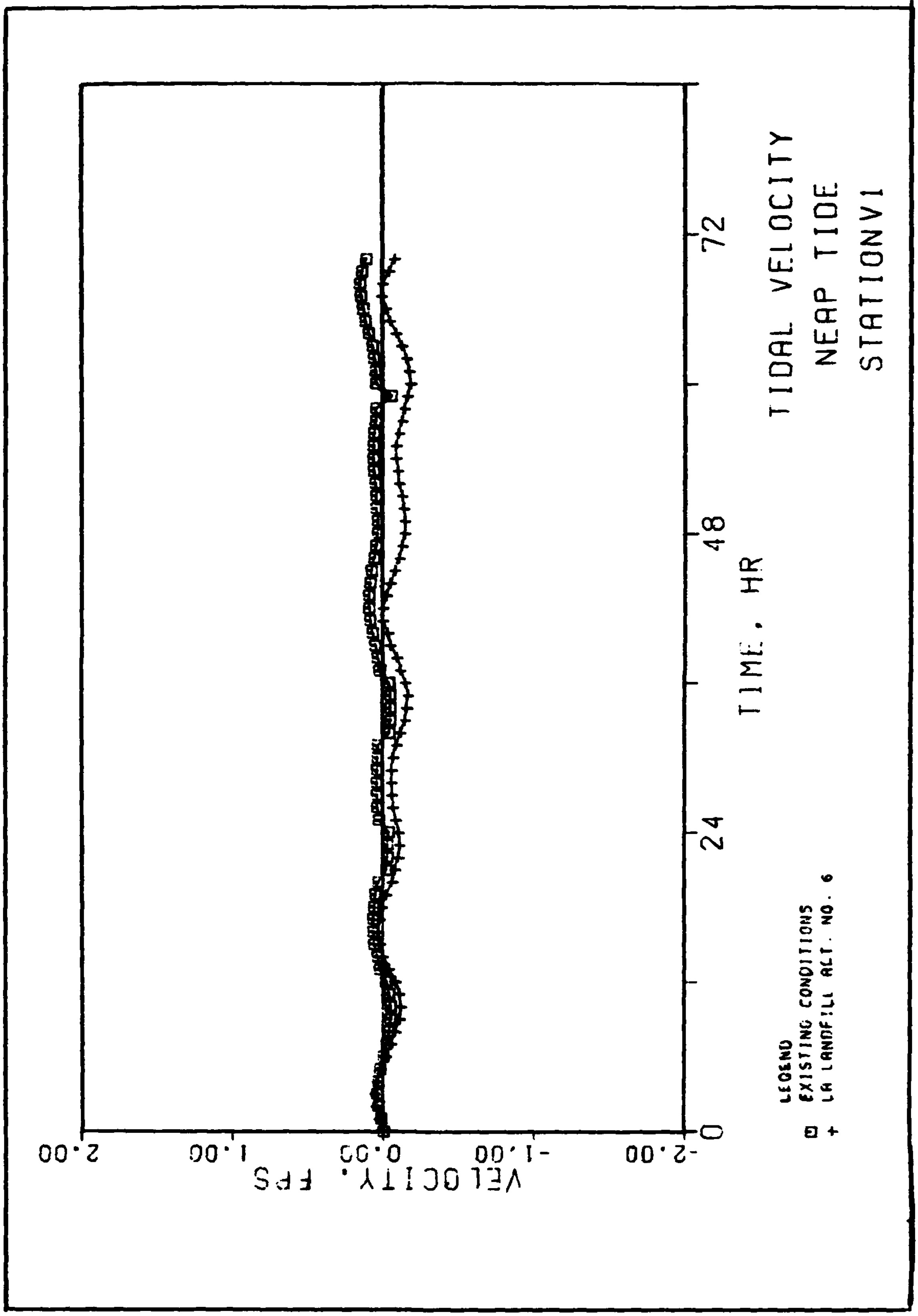

TIDAL VELOCITY
NEAP TIDE
STATIONV1
TIME, HR
VELOCITY, FPS
2.00
1.00
0.00
-1.00
-2.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 50

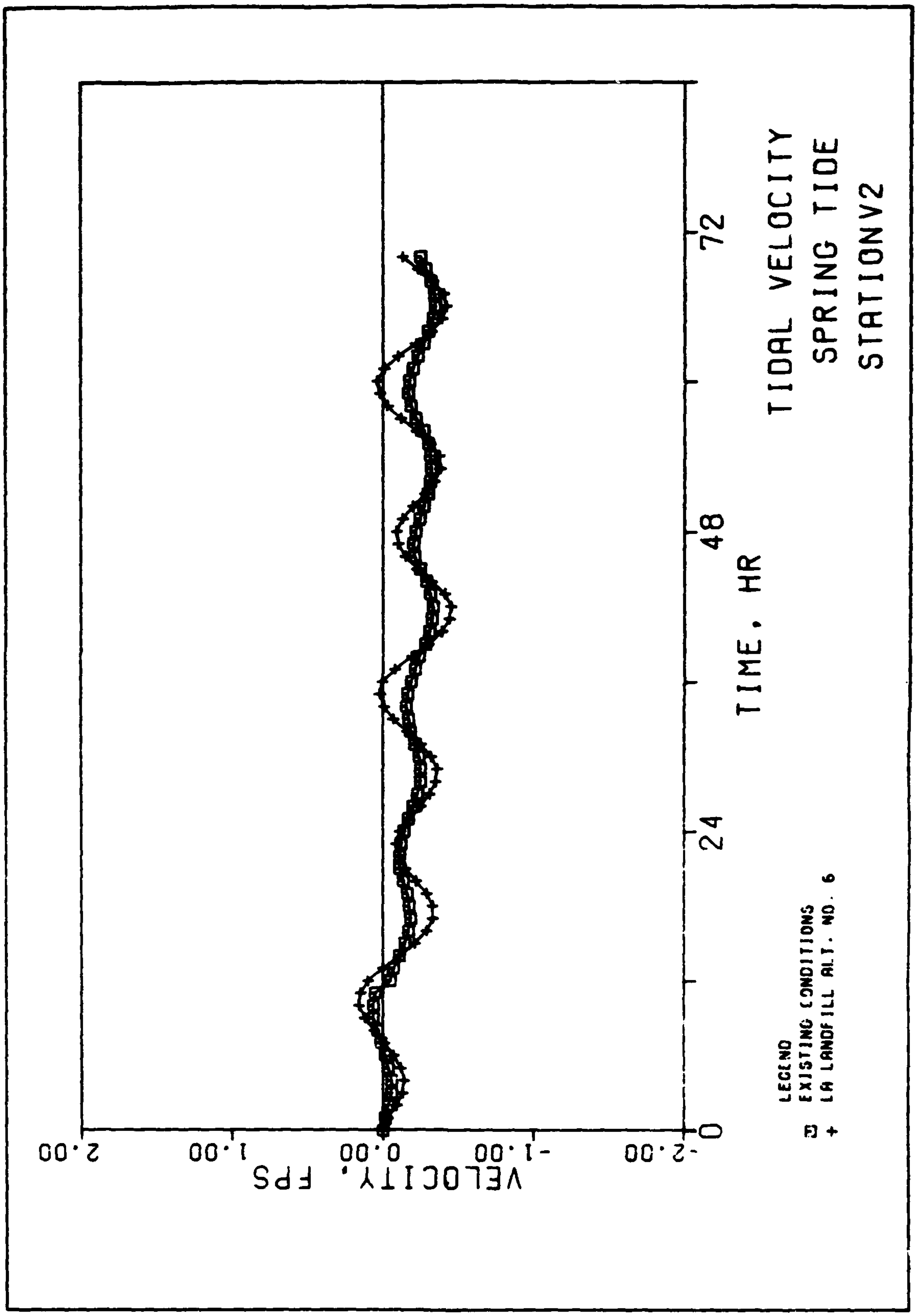
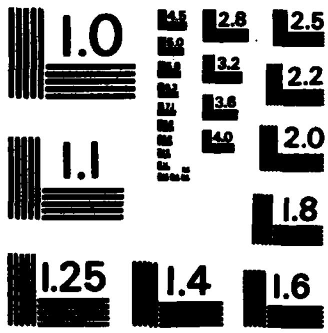

TIDAL VELOCITY
SPRING TIDE
STATIONV2
TIME, HR
VELOCITY, FPS
2.00
1.00
0.00
-1.00
-2.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 51

AD-A159 448 LOS ANGELES AND LONG BEACH HARBORS MODEL STUDY DEEP-DRAFT DRY BULK EXPORT..(U) COASTAL ENGINEERING RESEARCH CENTER VICKSBURG MS W C SEABERGH JUL 85

UNCLASSIFIED CERC-85-8 F/G 8/3 NL



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

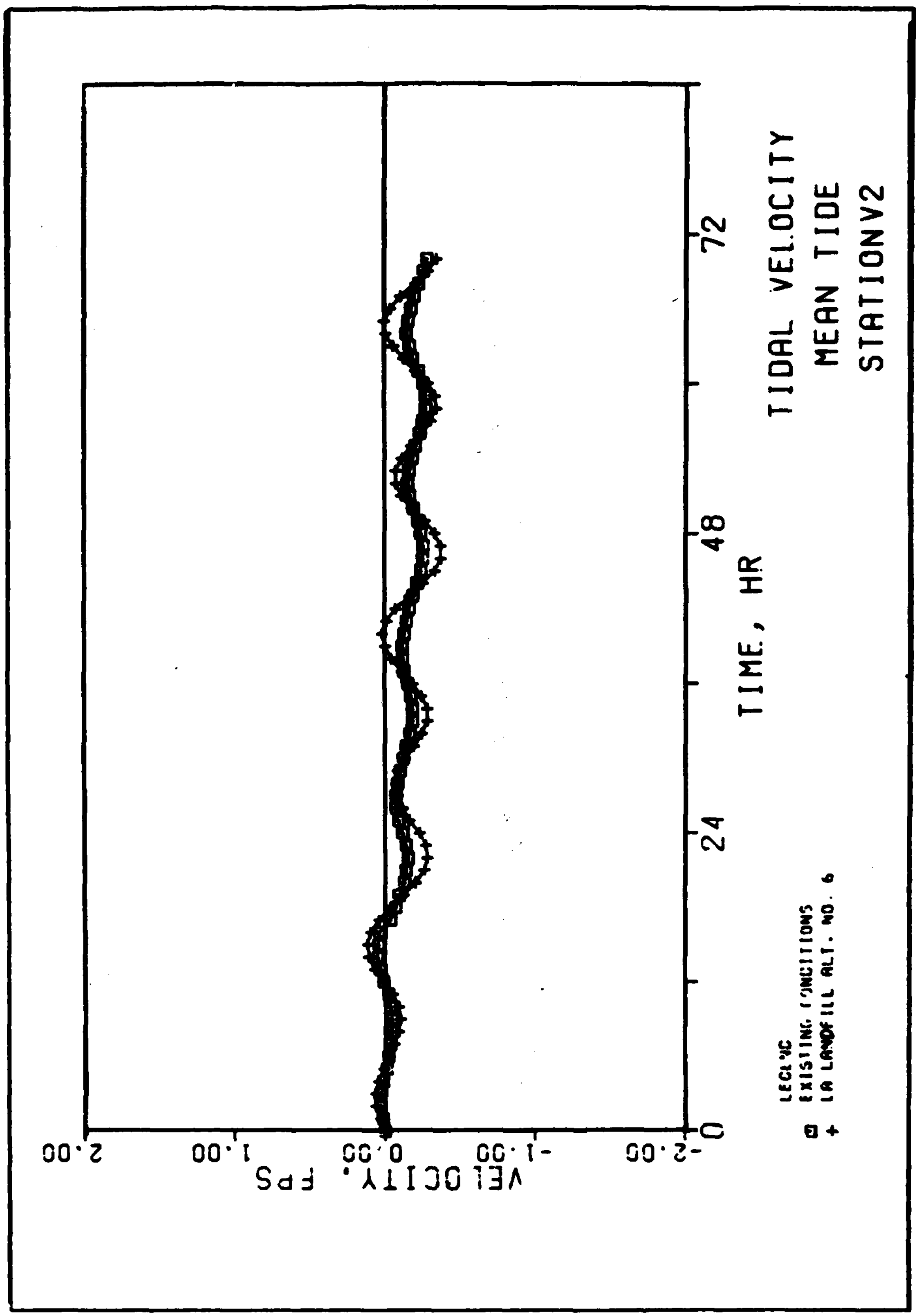

TIDAL VELOCITY
MEAN TIDE
STATIONV2
TIME, HR
VELOCITY, FPS
0
24
48
72
2.00
1.00
0.00
-1.00
-2.00
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 52

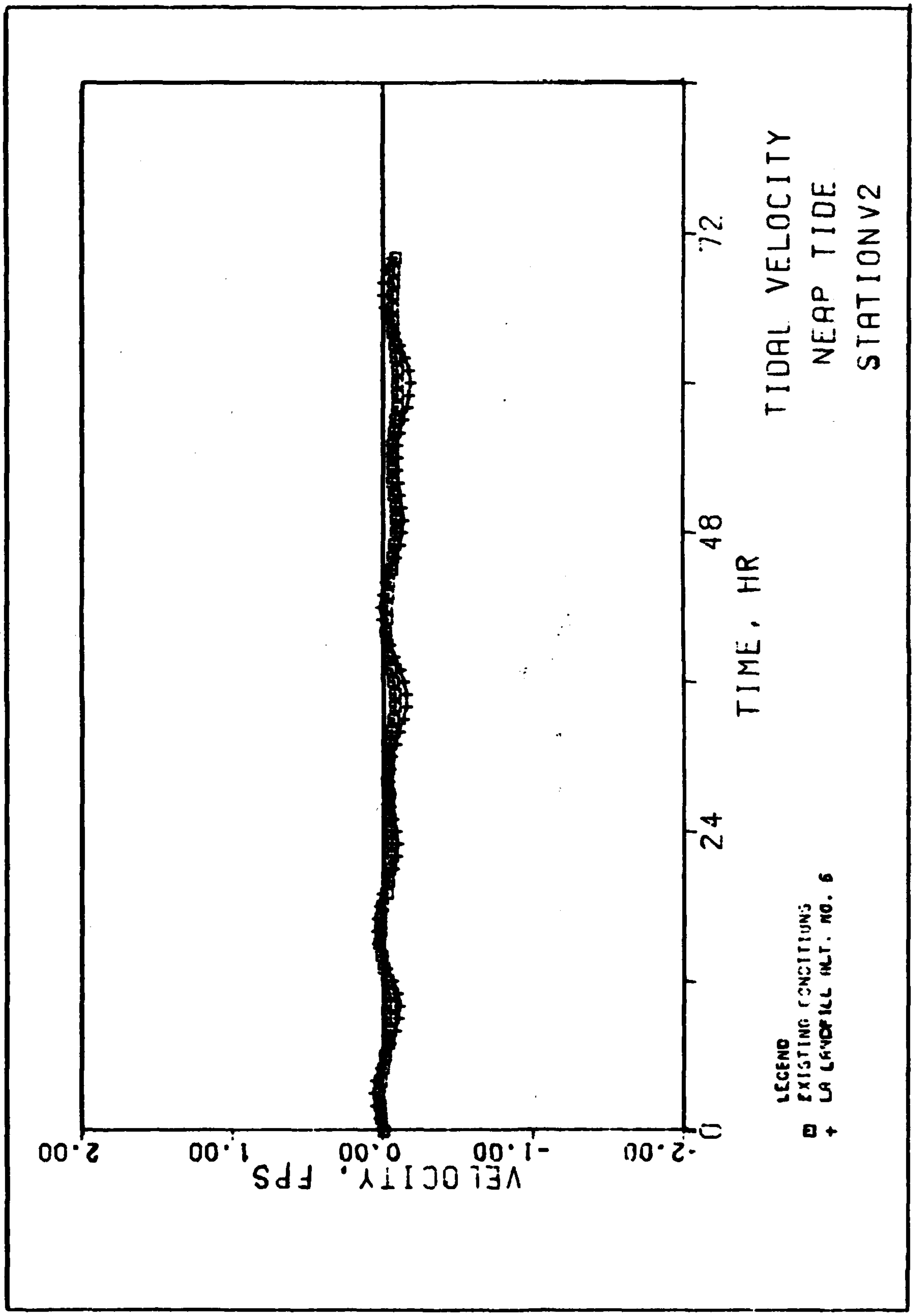

TIDAL VELOCITY
NEAP TIDE
STATION V2
TIME, HR
VELOCITY, FPS
2.00
1.00
0.00
-1.00
-2.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 53

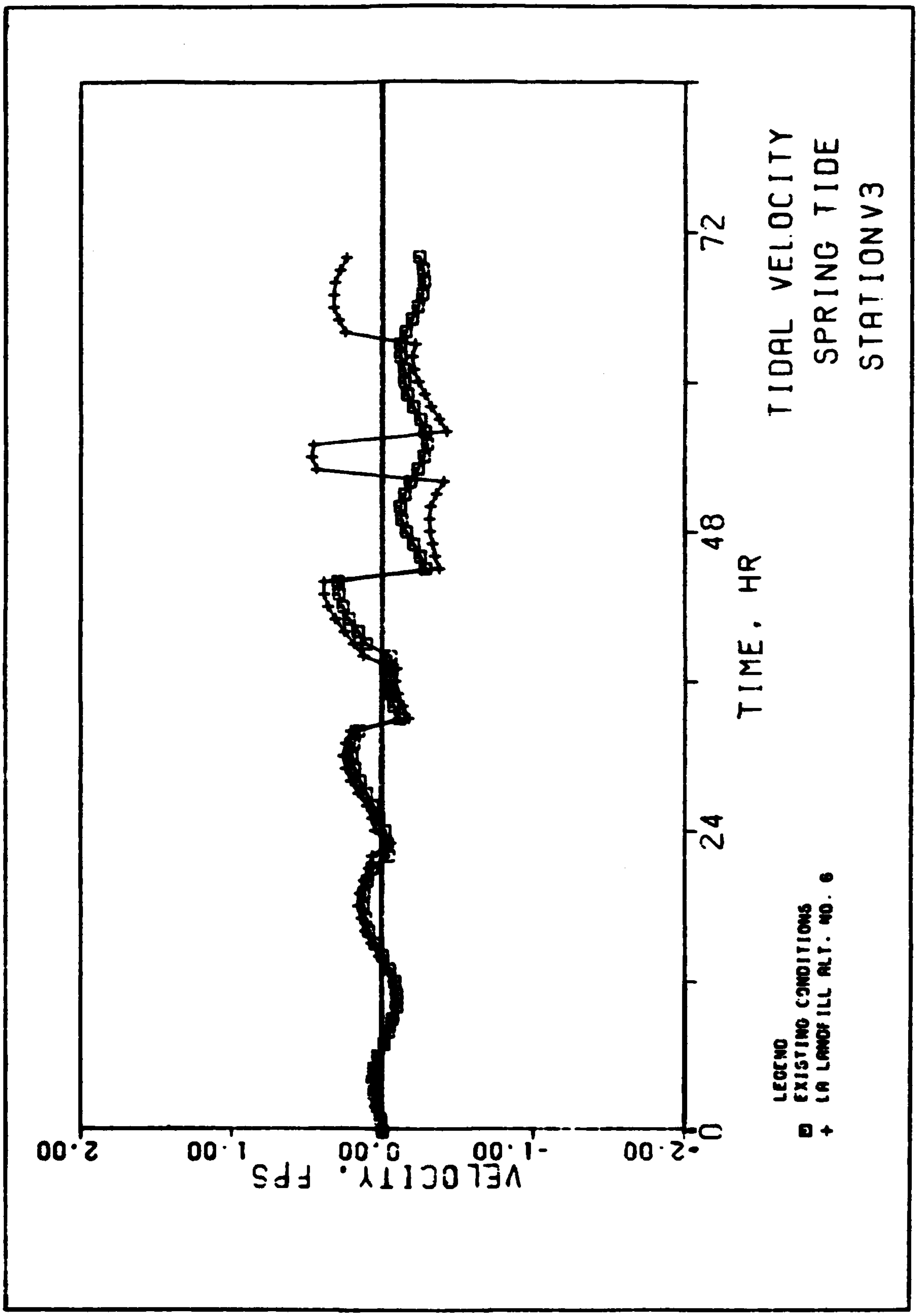
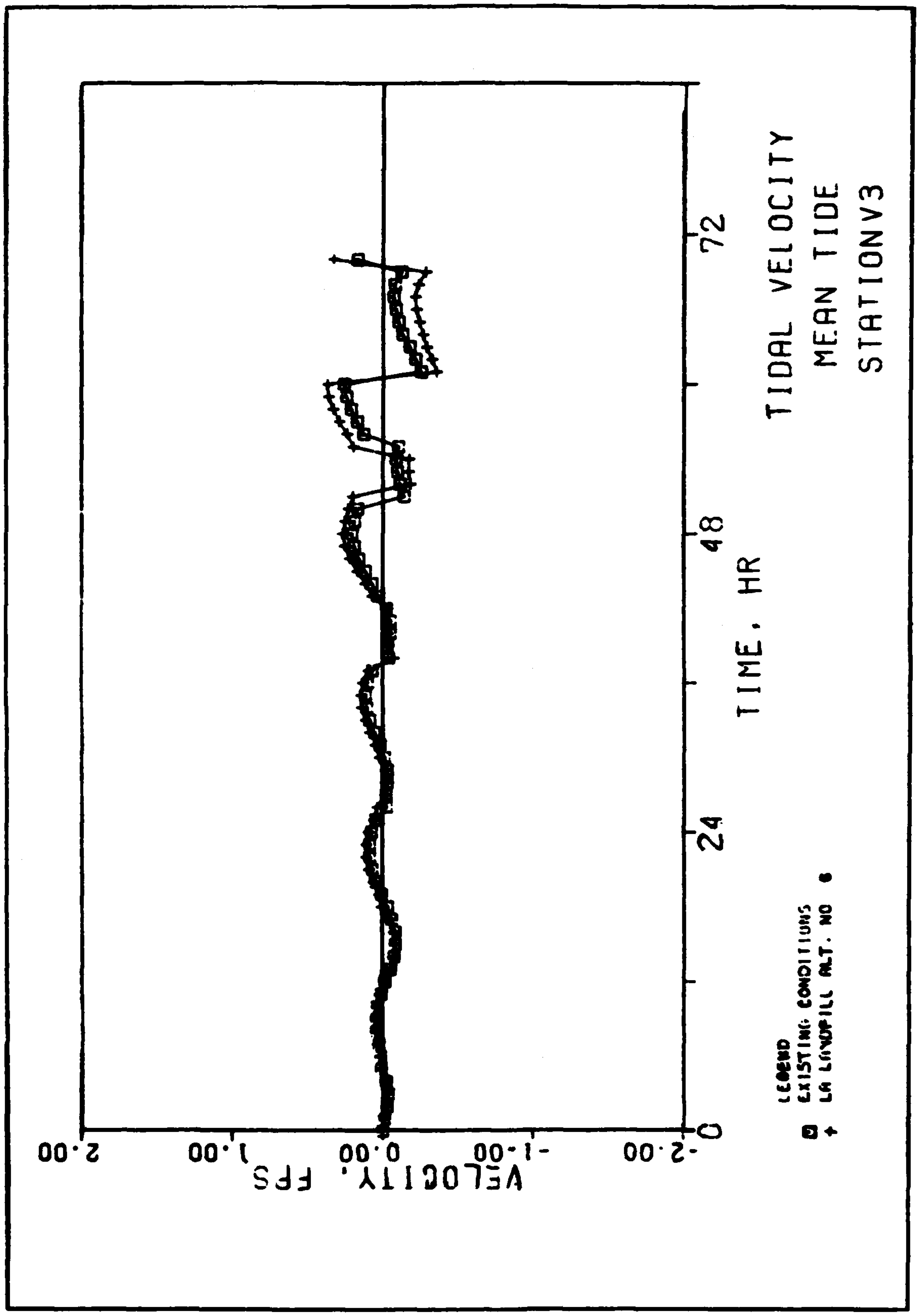
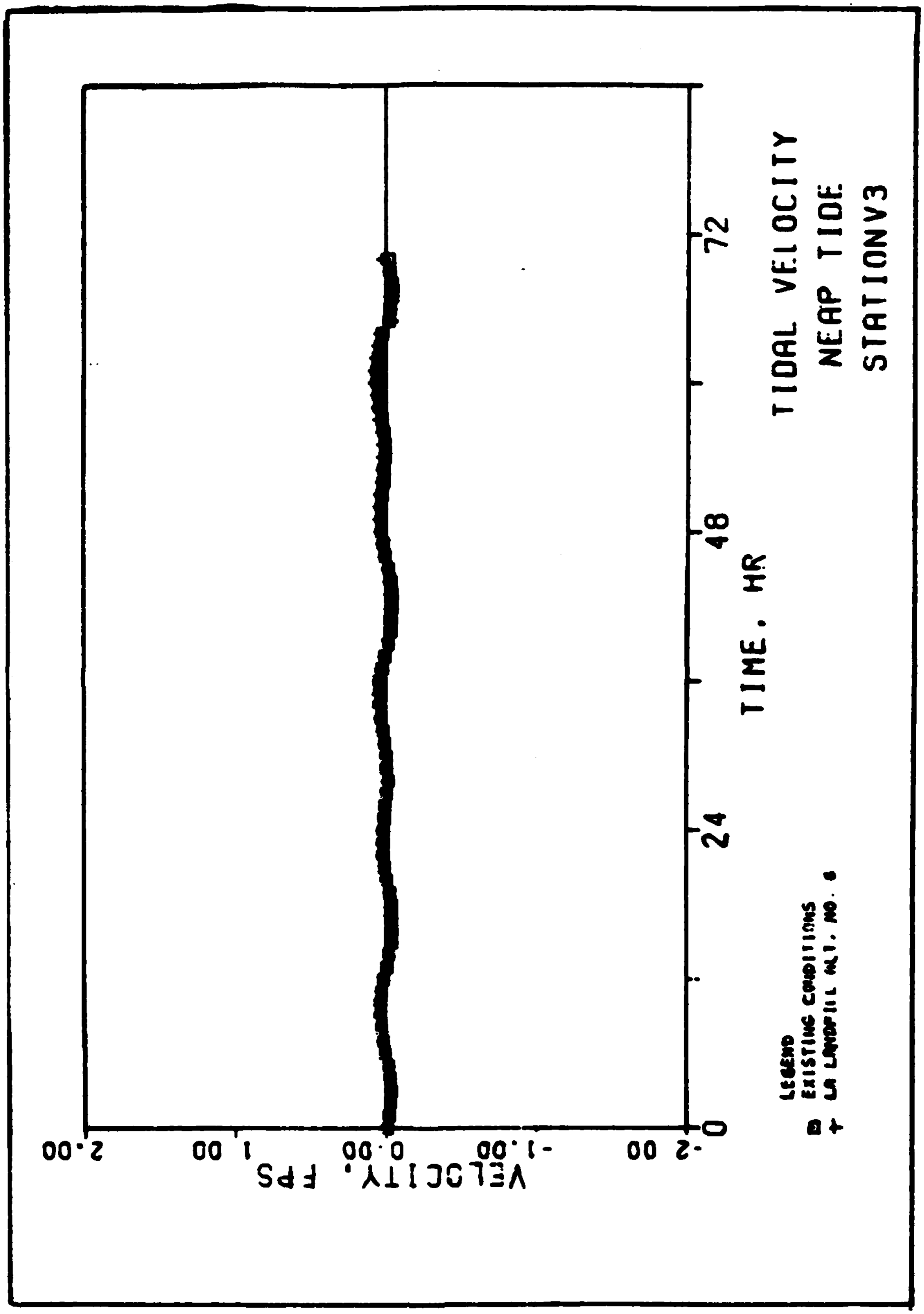

TIDAL VELOCITY
SPRING TIDE
STATIONV3
TIME, HR
VELOCITY, FPS
0
24
48
72
2.00
1.00
0.00
-1.00
-2.00
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 54

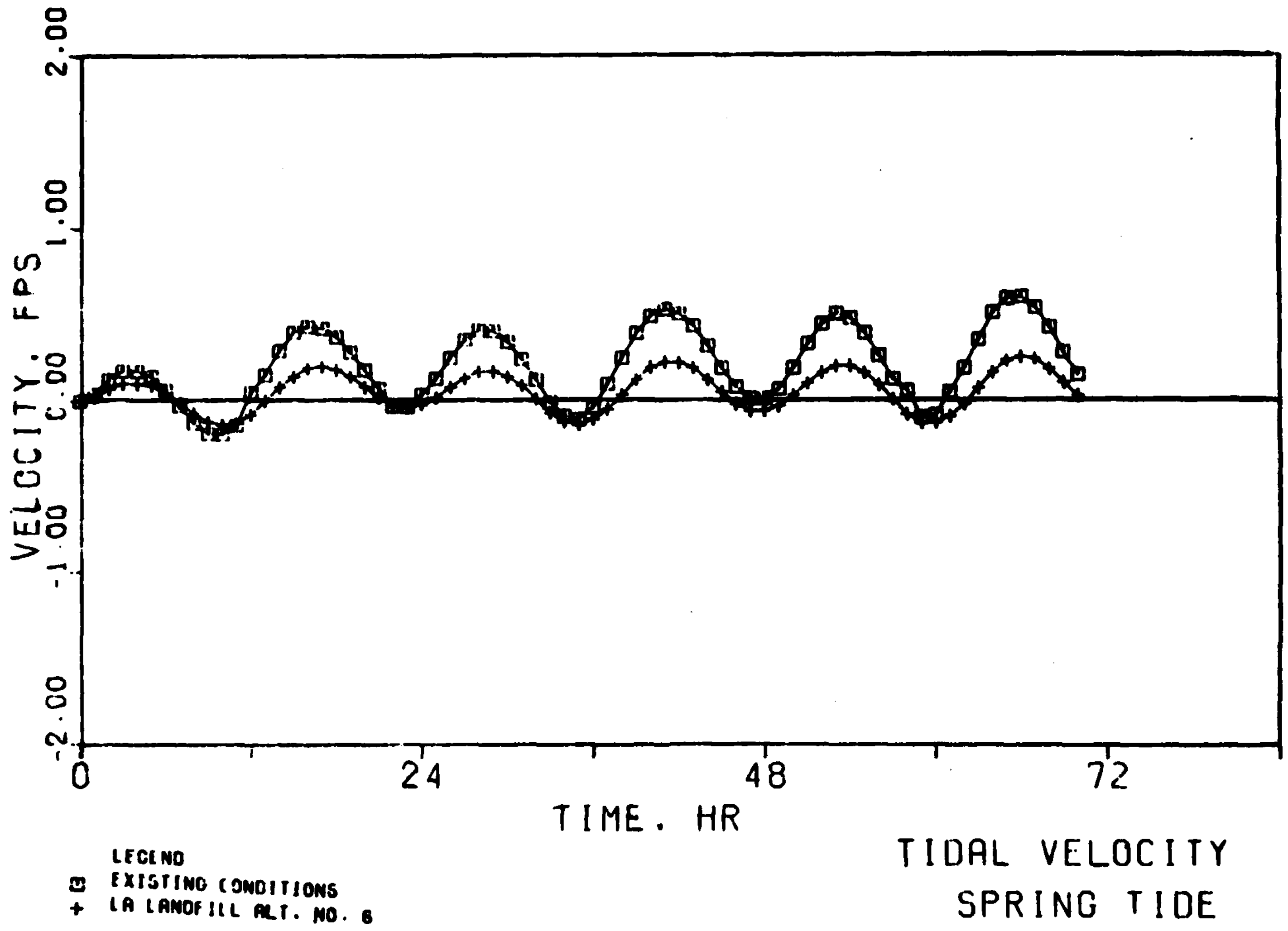


TIDAL VELOCITY
MEAN TIDE
STATIONV3
VELOCITY, FPS
TIME, HR
2.00
1.00
0.00
-1.00
-2.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO 6



TIDAL VELOCITY
NEAP TIDE
STATIONV3
TIME, HR
VELOCITY, FPS
2.00
1.00
0.00
-1.00
-2.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO.

PLATE 56


2.00
1.00
0.00
-1.00
-2.00
VELOCITY, FPS
0
24
48
72
TIME, HR
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6
TIDAL VELOCITY
SPRING TIDE
STATIONV4

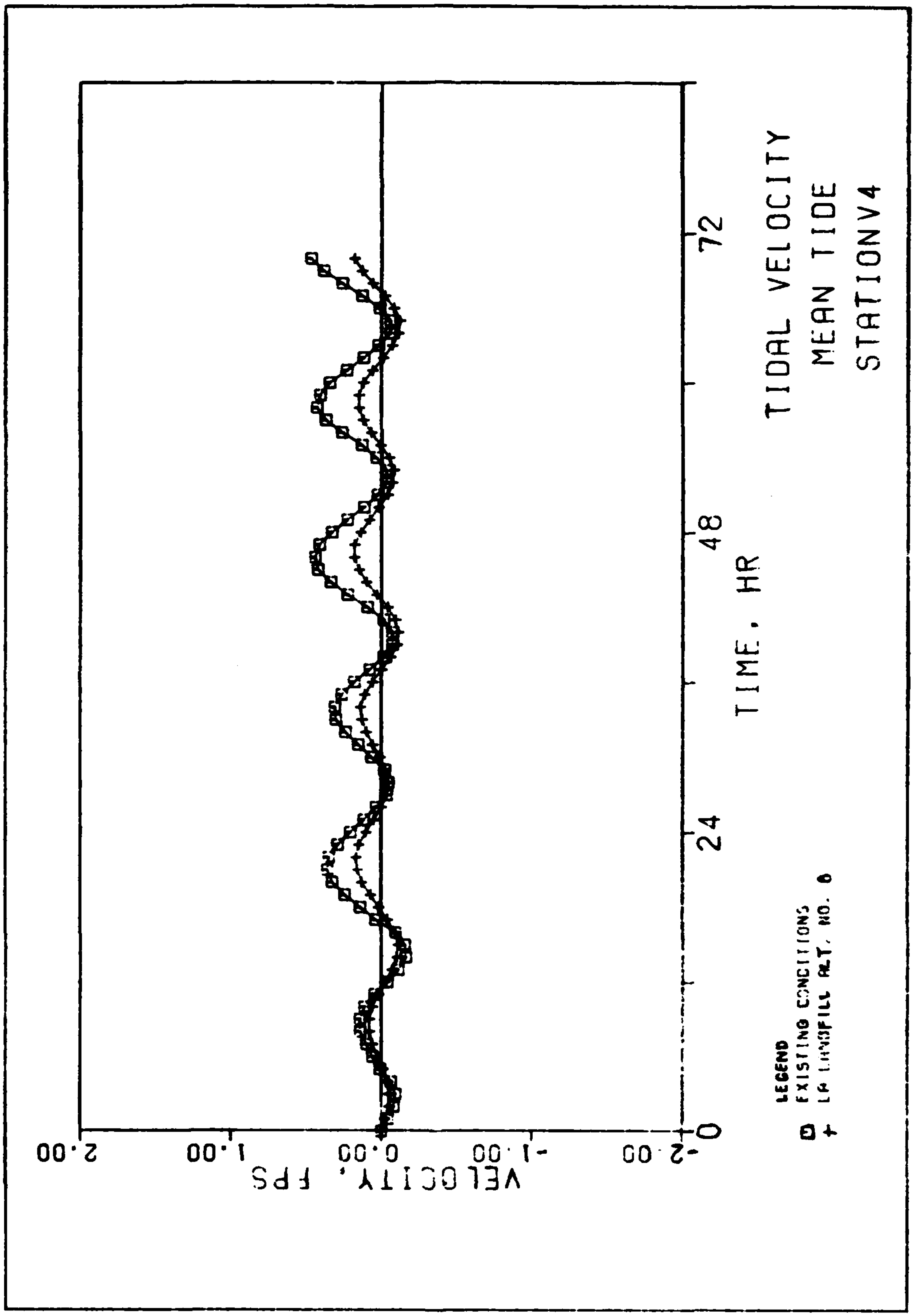

TIDAL VELOCITY
MEAN TIDE
STATIONV4
TIME, HR
VELOCITY, FPS
2.00
1.00
0.00
-1.00
-2.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 58

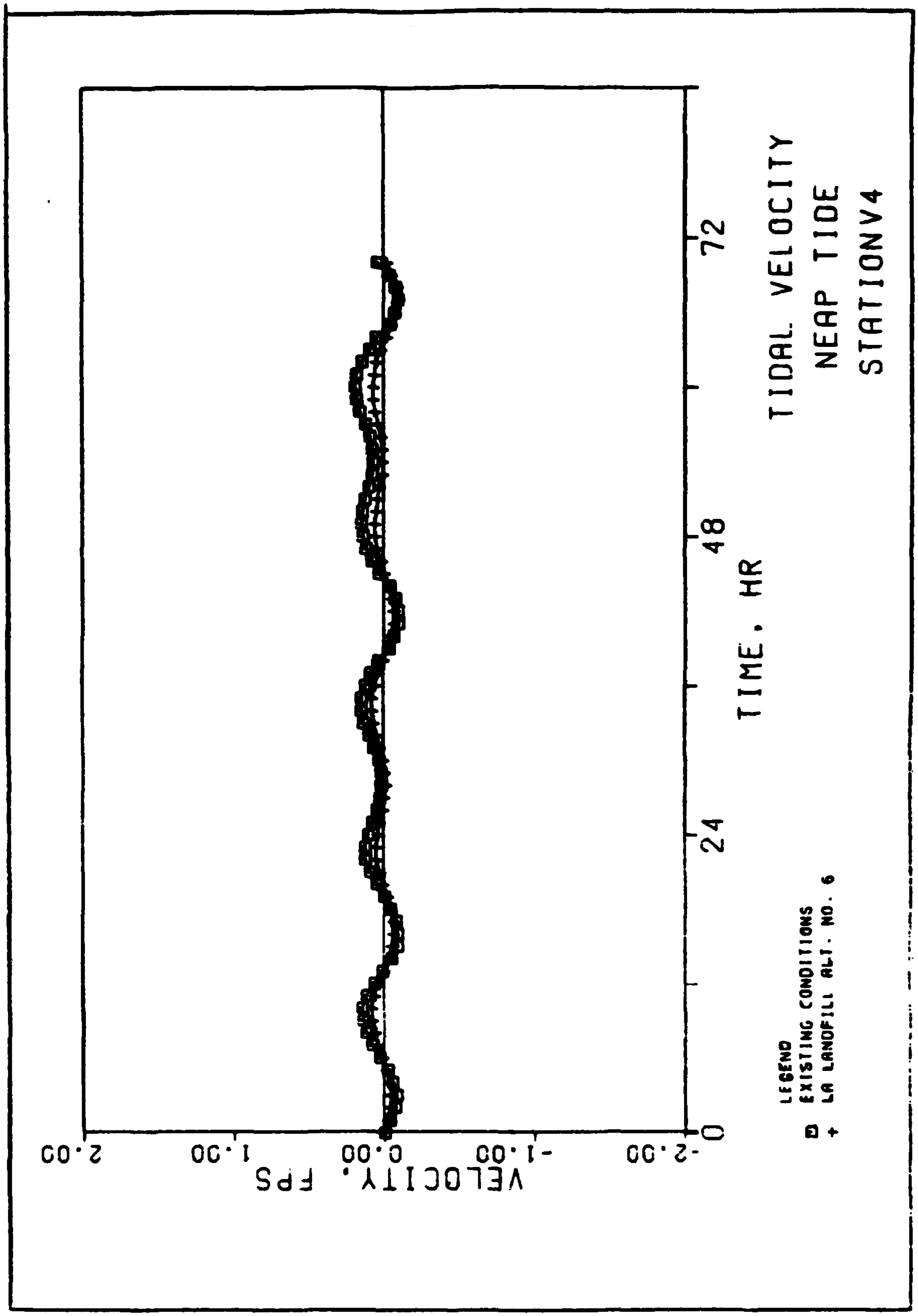

TIDAL VELOCITY
NEAP TIDE
STATIONV4
VELOCITY, FPS
TIME, HR
2.00
1.00
0.00
-1.00
-2.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 59

10

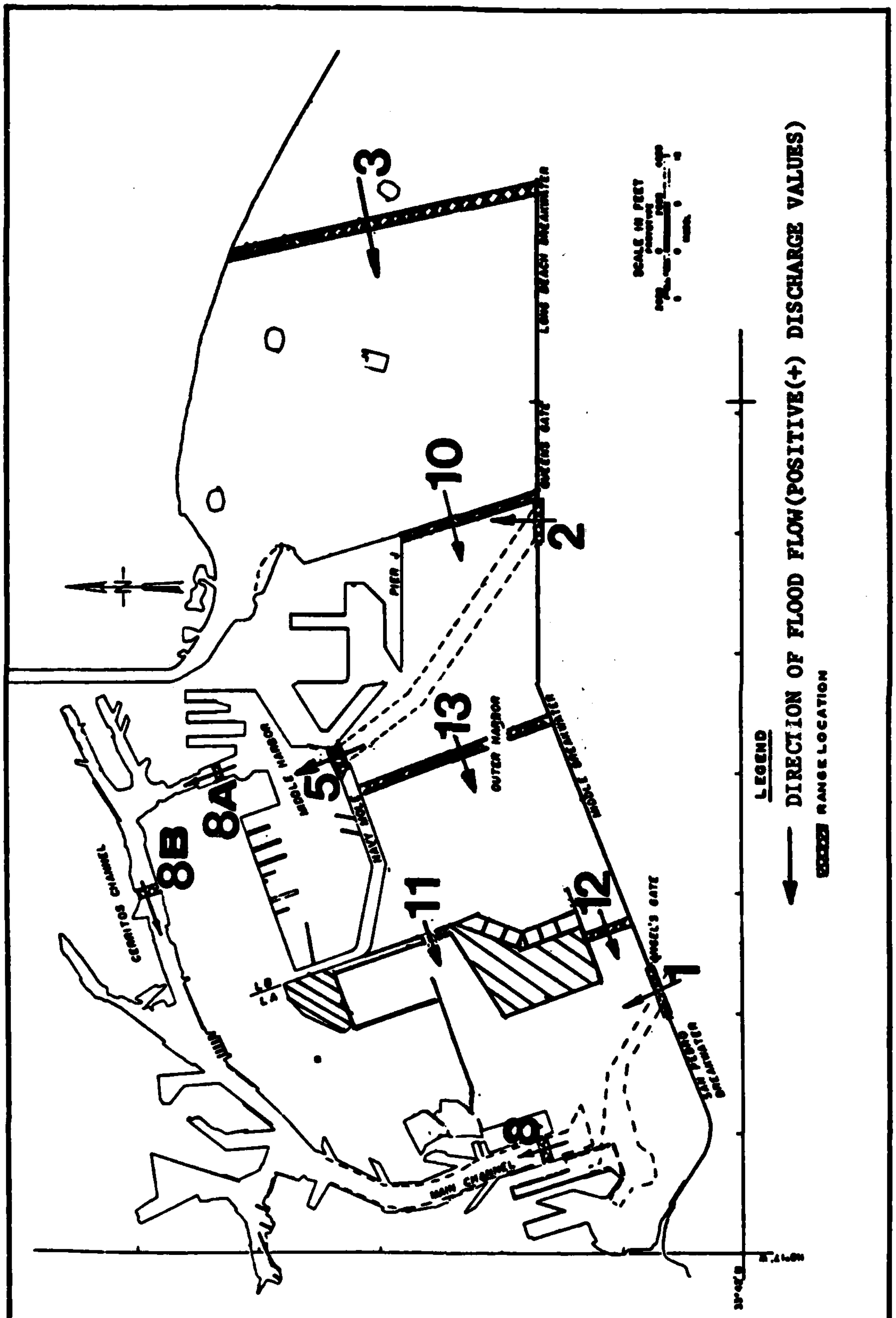
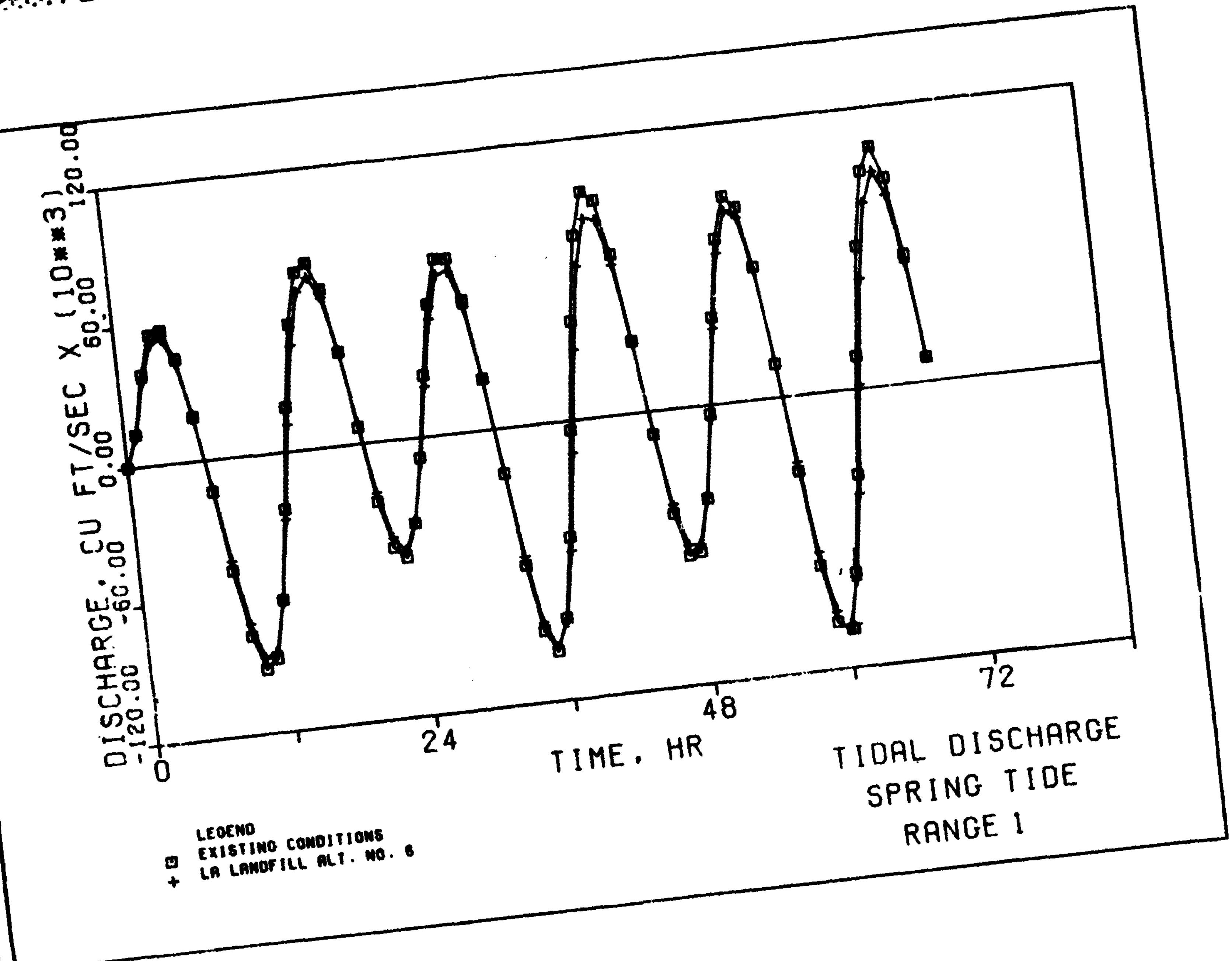
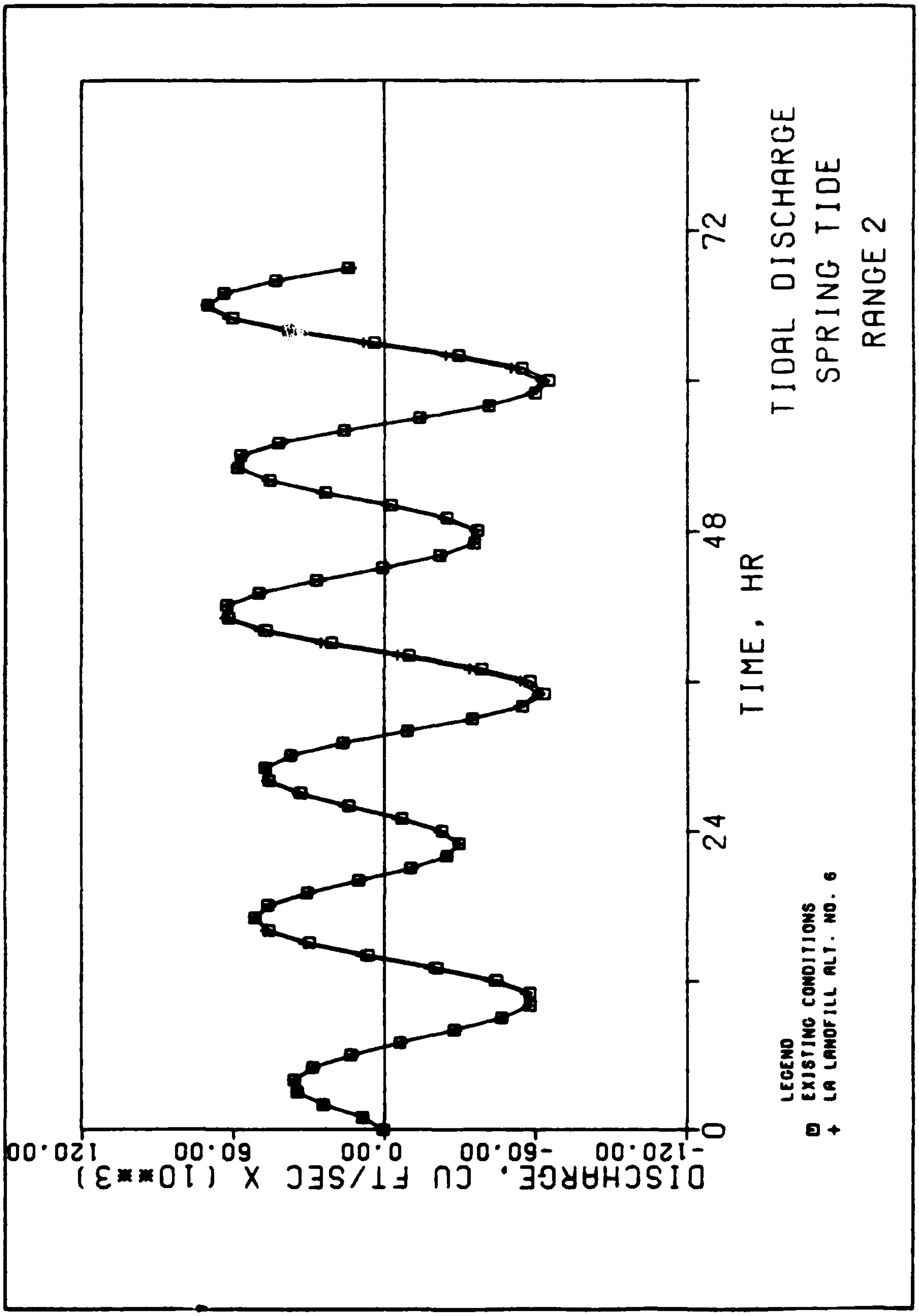
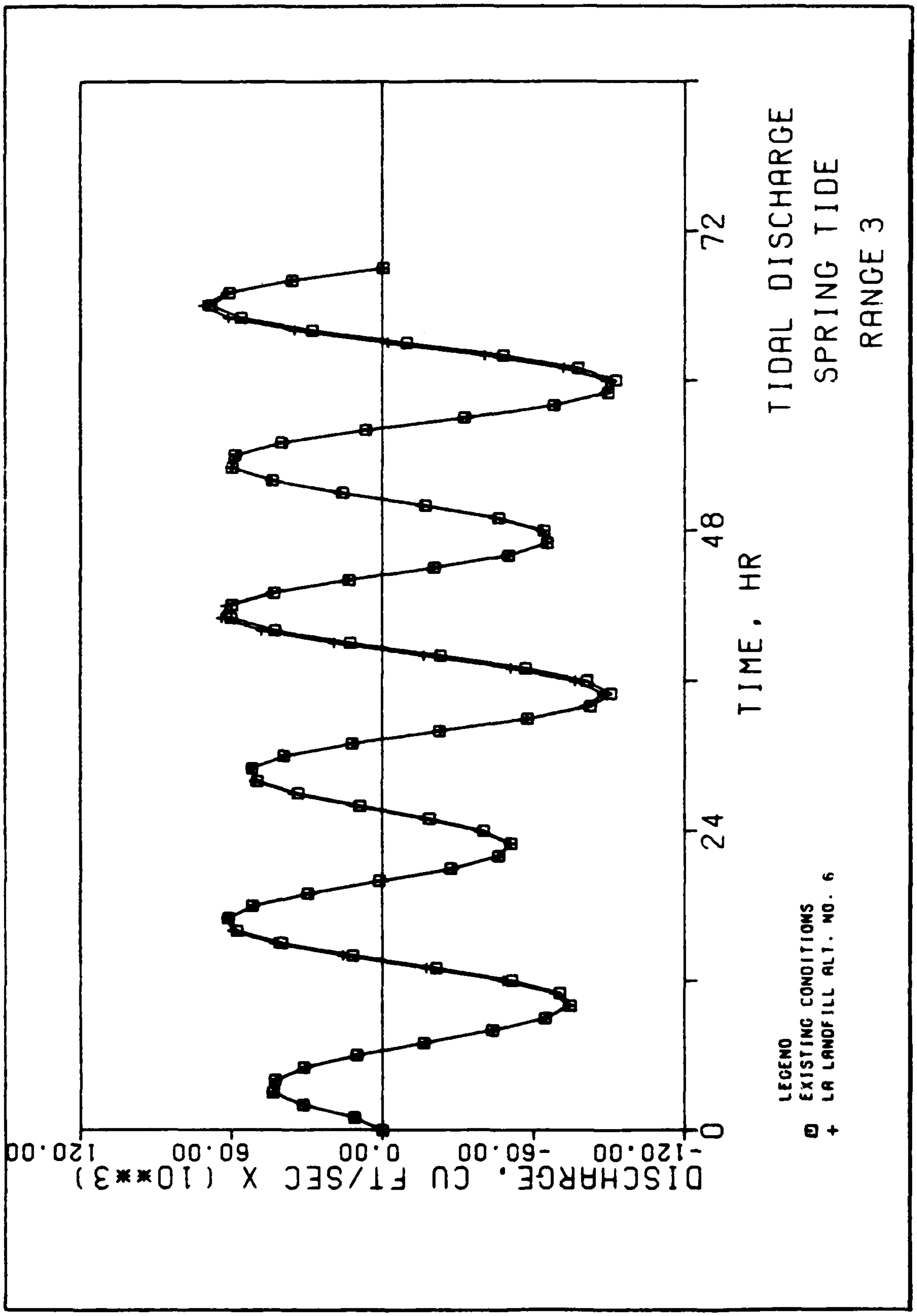

3
10
2
13
5
8A
8B
11
12
1
8
PIER J
MIDDLE HARBOR
OUTER HARBOR
NAVY MOLE
CERRITOS CHANNEL
MAIN CHANNEL
LONG BEACH BREAKWATER
QUEENS GATE
MIDDLE BREAKWATER
ANGEL'S GATE
SAN PEDRO BREAKWATER
SCALE IN FEET
LEGEND
DIRECTION OF FLOOD FLOW(POSITIVE(+) DISCHARGE VALUES)
RANGE LOCATION

PLATE 60


DISCHARGE, CU FT/SEC X (10**3)
120.00
60.00
0.00
-60.00
-120.00
0
24
48
72
TIME, HR
TIDAL DISCHARGE
SPRING TIDE
RANGE 1
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6


TIDAL DISCHARGE
SPRING TIDE
RANGE 2
TIME, HR
DISCHARGE, CU FT/SEC X (10**3)
120.00
60.00
0.00
-60.00
-120.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6



TIDAL DISCHARGE
SPRING TIDE
RANGE 3
TIME, HR
DISCHARGE, CU FT/SEC X (10**3)
-120.00
-60.00
0.00
60.00
120.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

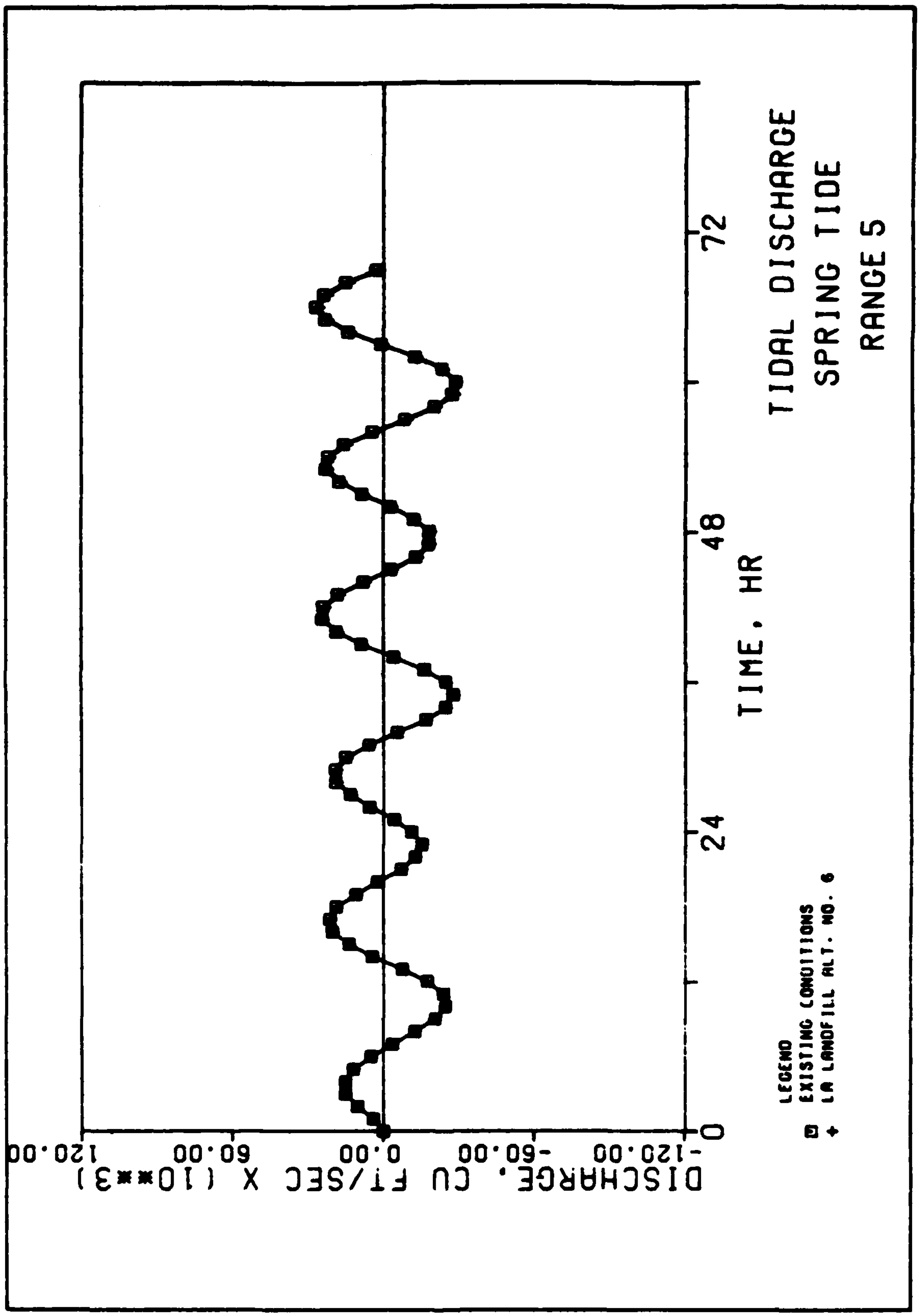

TIDAL DISCHARGE
SPRING TIDE
RANGE 5
TIME, HR
DISCHARGE, CU FT/SEC X (10**3)
-120.00
-60.00
0.00
60.00
120.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 64

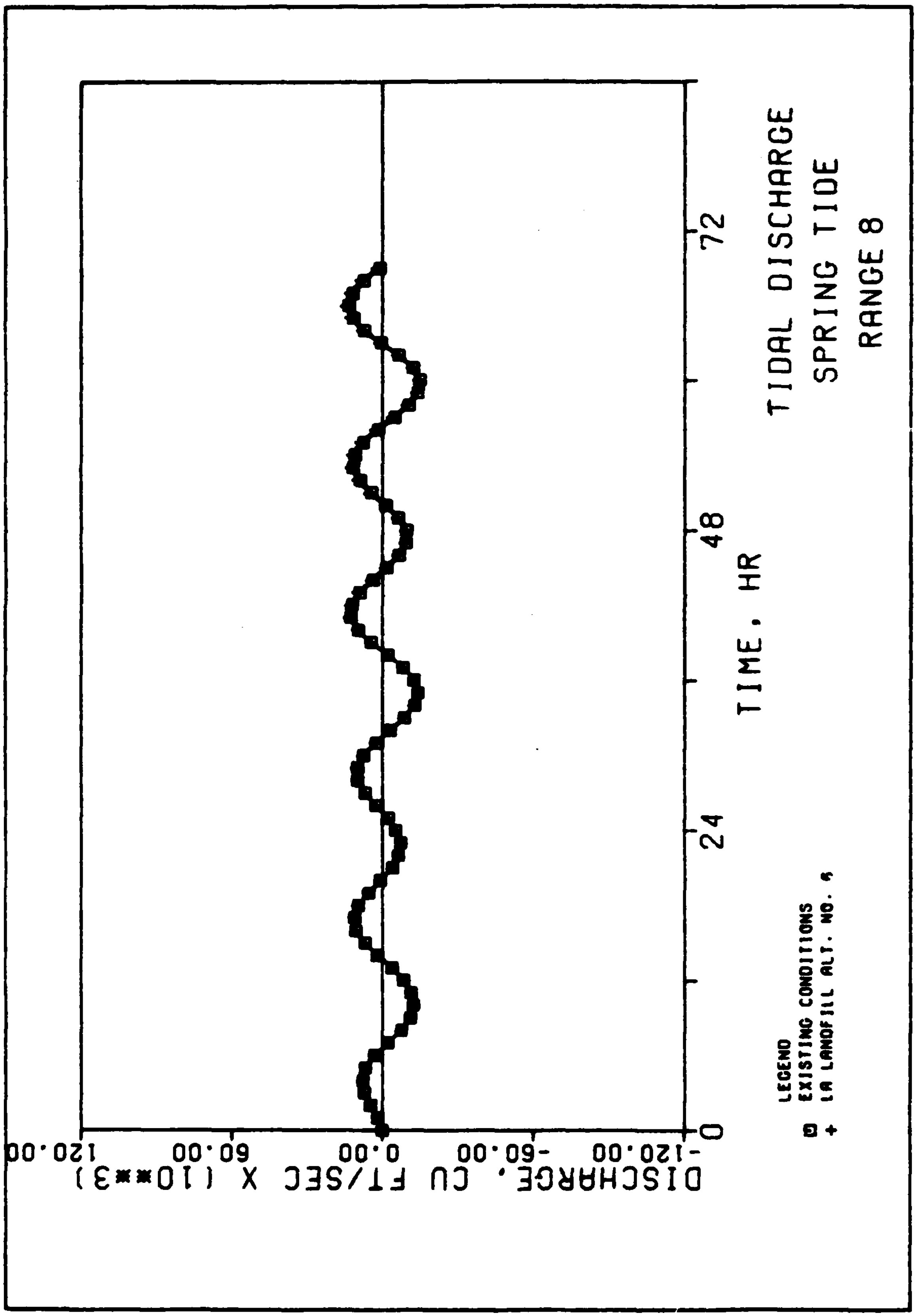
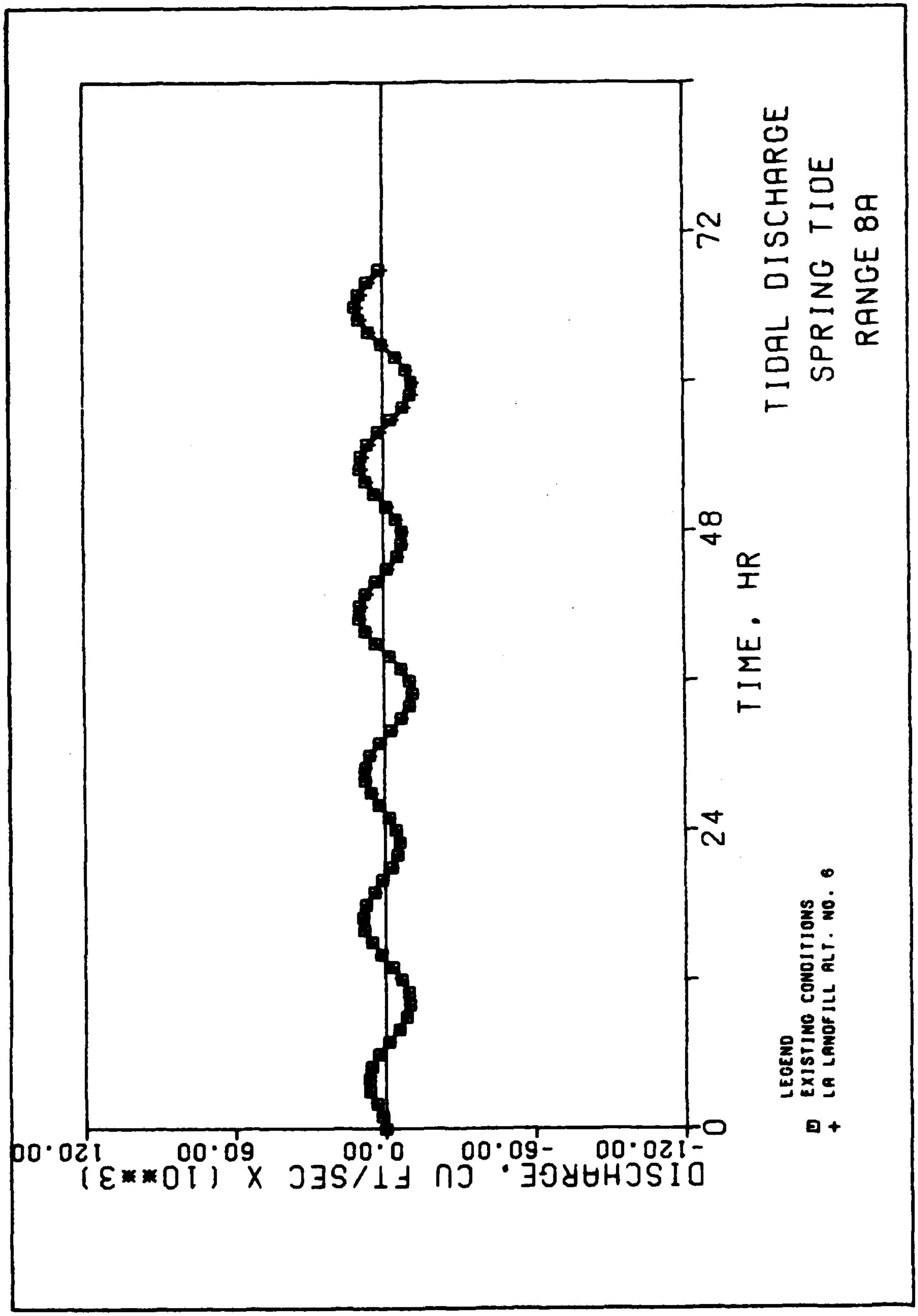
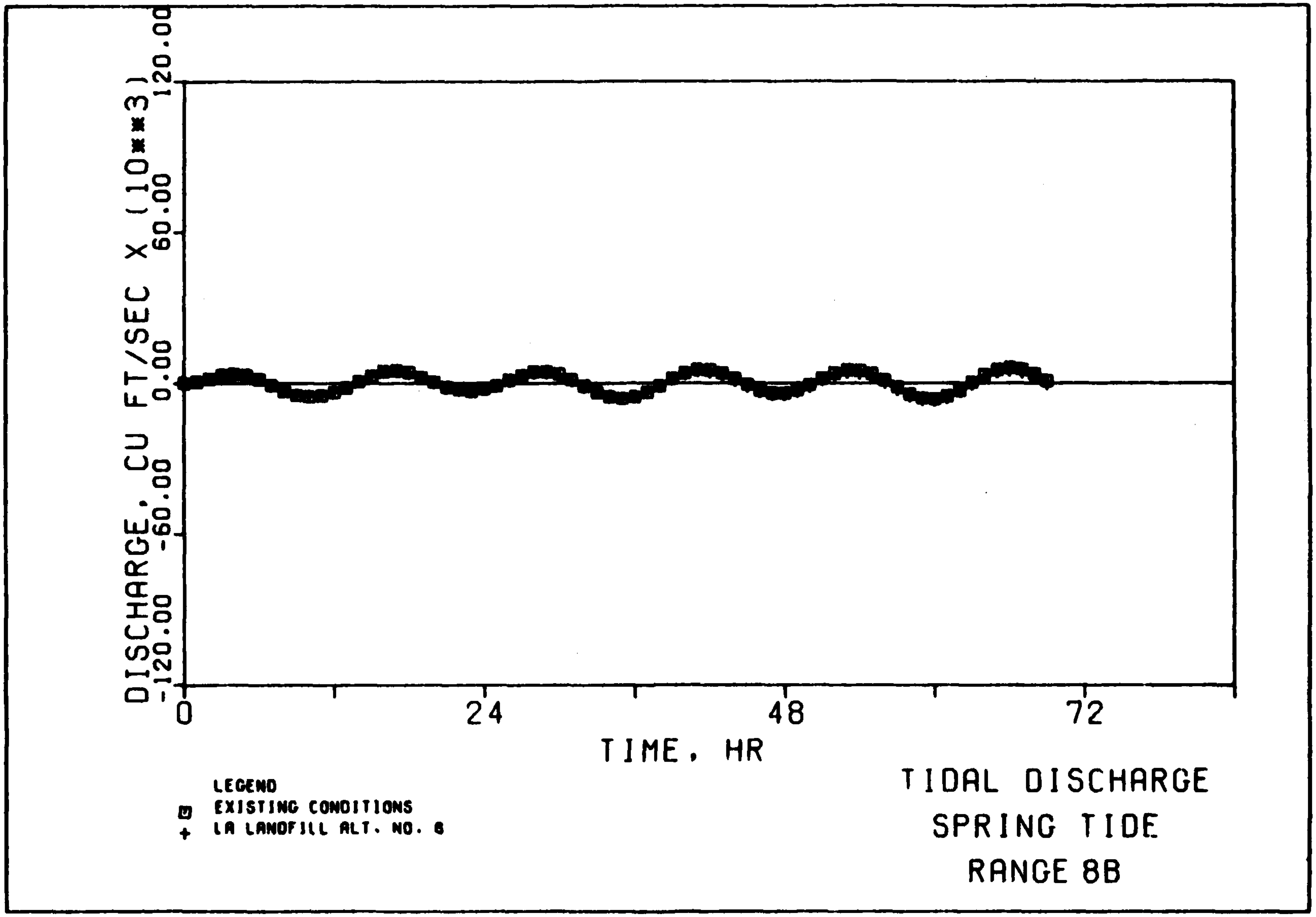
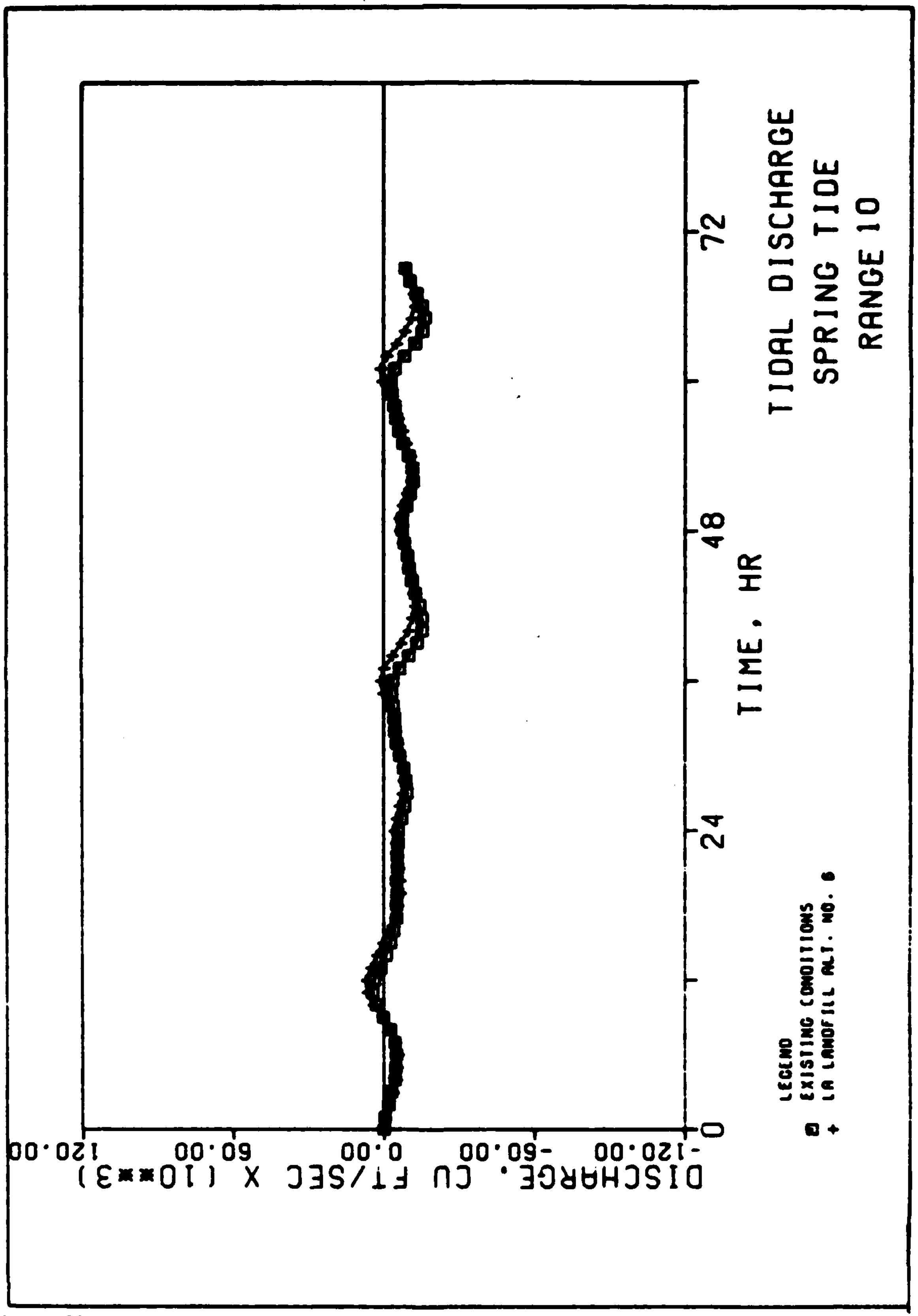

TIDAL DISCHARGE
SPRING TIDE
RANGE 8
TIME, HR
DISCHARGE, CU FT/SEC X (10**3)
120.00
60.00
0.00
-60.00
-120.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 65



TIDAL DISCHARGE
SPRING TIDE
RANGE 8A
TIME, HR
DISCHARGE, CU FT/SEC X (10**3)
120.00
60.00
0.00
-60.00
-120.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6


DISCHARGE, CU FT/SEC X (10**3)
120.00
60.00
0.00
-60.00
-120.00
0
24
48
72
TIME, HR
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6
TIDAL DISCHARGE
SPRING TIDE
RANGE 8B



TIDAL DISCHARGE
SPRING TIDE
RANGE 10
TIME, HR
0
24
48
72
DISCHARGE, CU FT/SEC X (10**3)
-120.00
-60.00
0.00
60.00
120.00
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 68

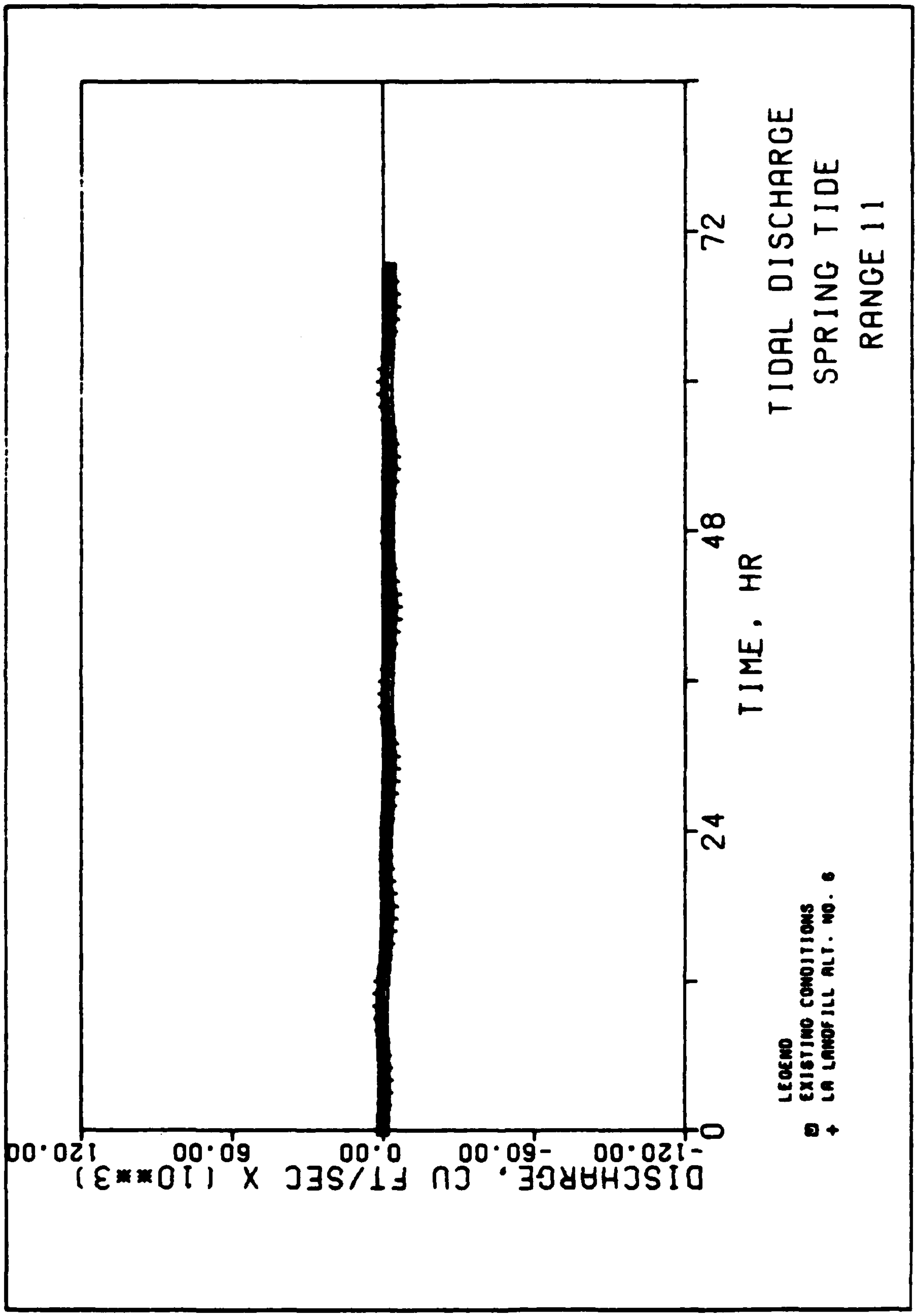

TIDAL DISCHARGE
SPRING TIDE
RANGE 11
TIME, HR
0
24
48
72
DISCHARGE, CU FT/SEC X (10**3)
-120.00
-60.00
0.00
60.00
120.00
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 69

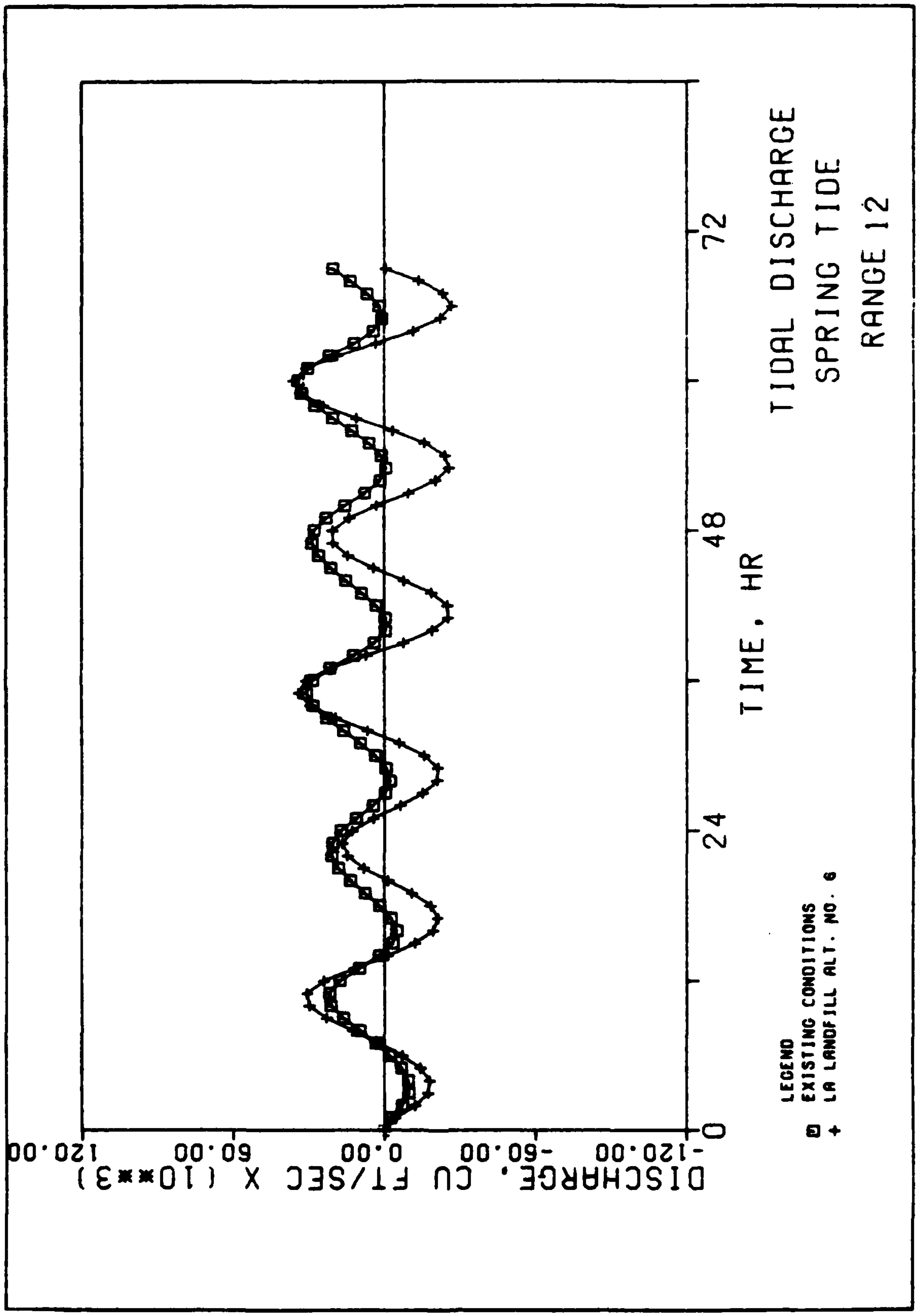
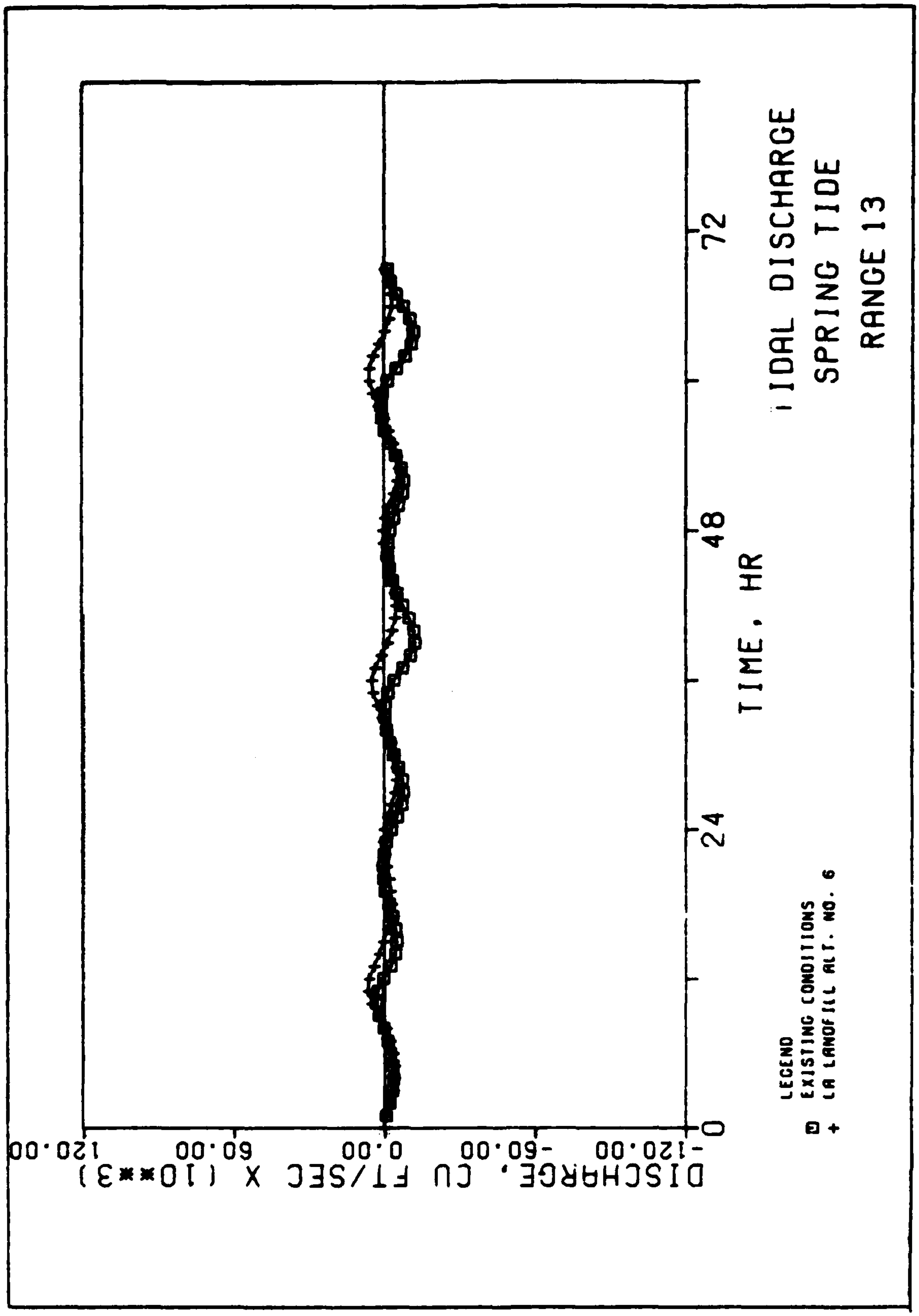

TIDAL DISCHARGE
SPRING TIDE
RANGE 12
TIME, HR
DISCHARGE, CU FT/SEC X (10**3)
-120.00
-60.00
0.00
60.00
120.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

PLATE 70


TIDAL DISCHARGE
SPRING TIDE
RANGE 13
TIME, HR
DISCHARGE, CU FT/SEC X (10**3)
120.00
60.00
0.00
-60.00
-120.00
0
24
48
72
LEGEND
EXISTING CONDITIONS
LA LANDFILL ALT. NO. 6

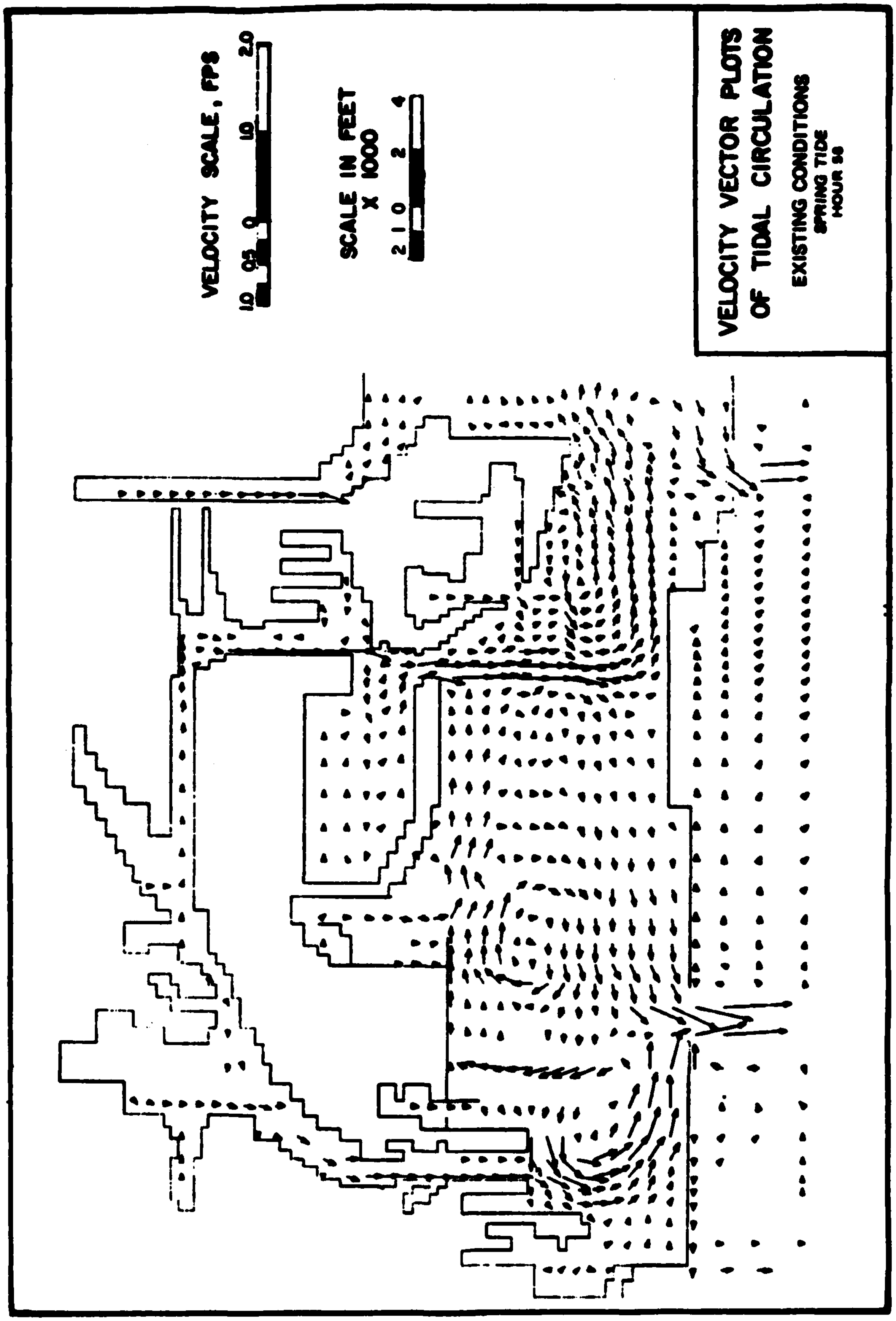
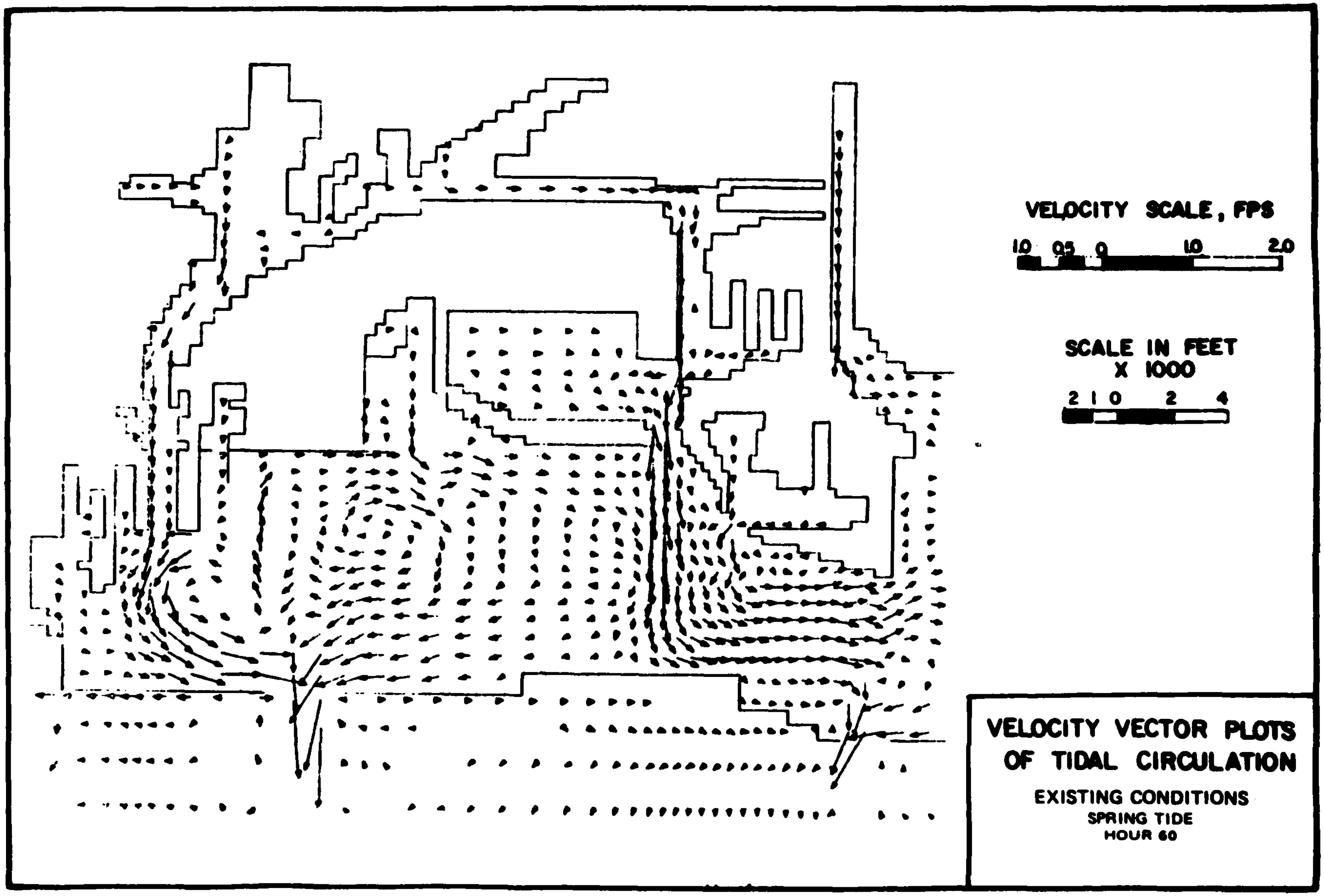

VELOCITY SCALE, FPS
1.0 0.5 0 1.0 2.0
SCALE IN FEET
X 1000
2 1 0 2 4
VELOCITY VECTOR PLOTS
OF TIDAL CIRCULATION
EXISTING CONDITIONS
SPRING TIDE
HOUR

PLATE 72



VELOCITY VECTOR PLOTS
OF TIDAL CIRCULATION
EXISTING CONDITIONS
SPRING TIDE
HOUR 60

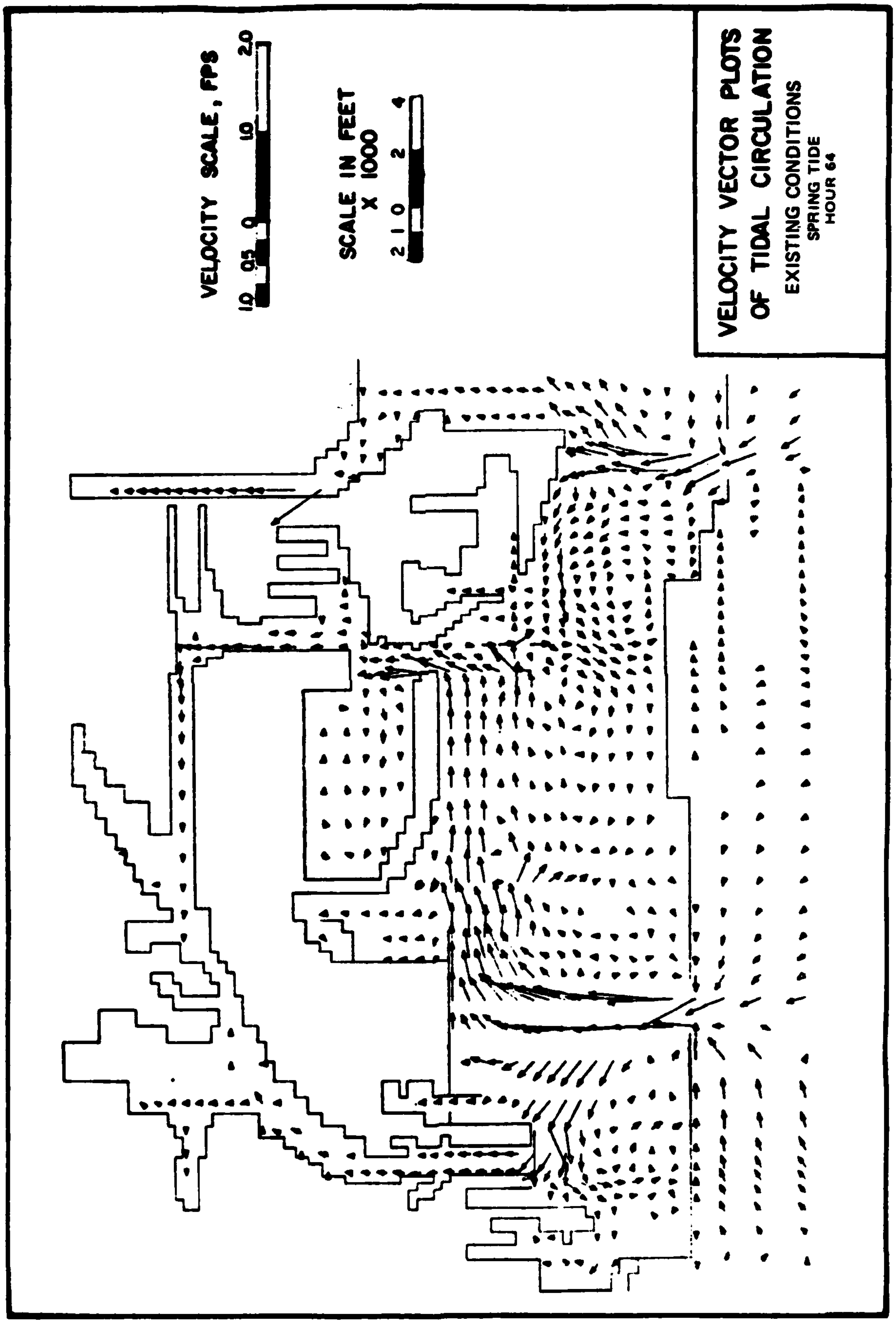
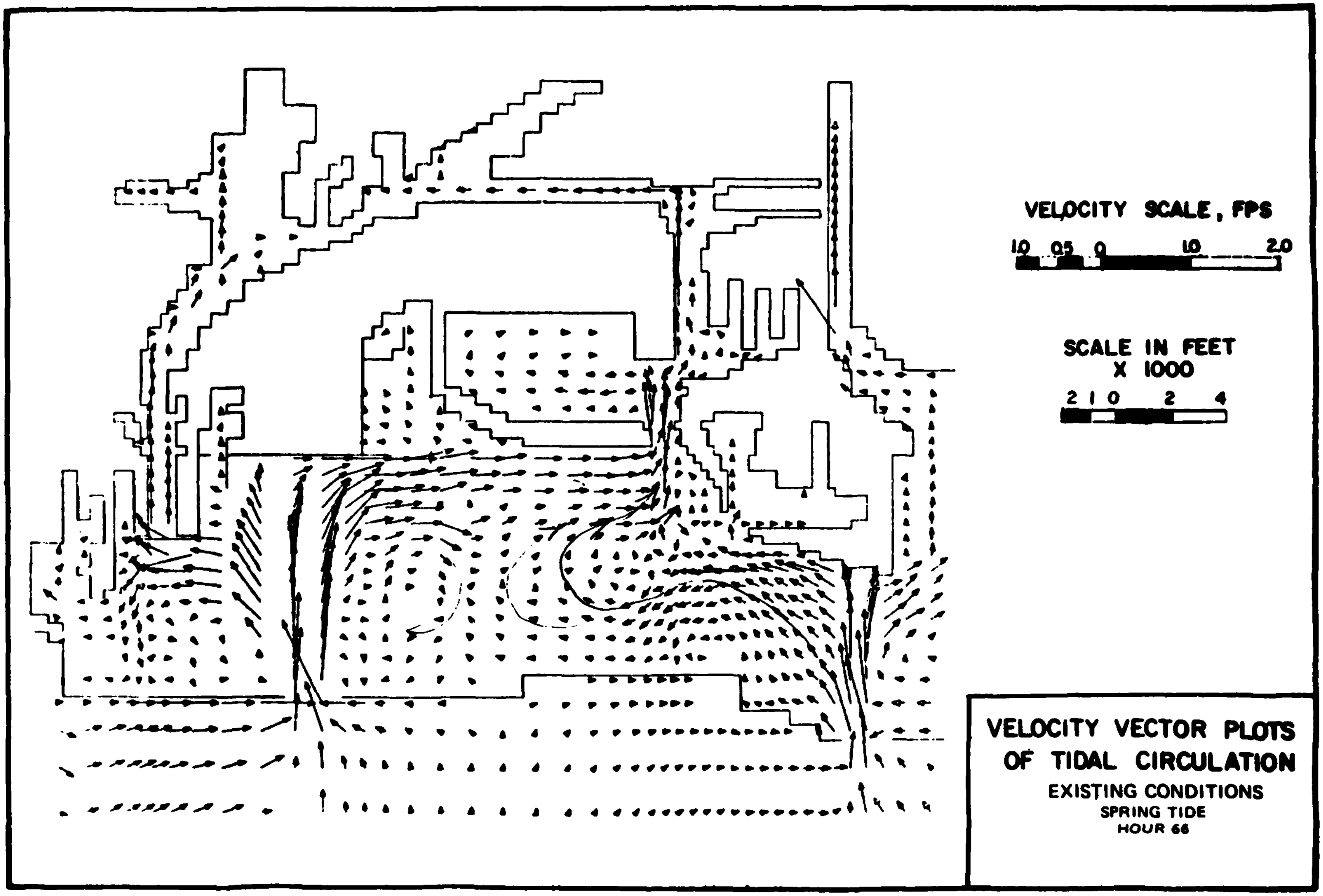
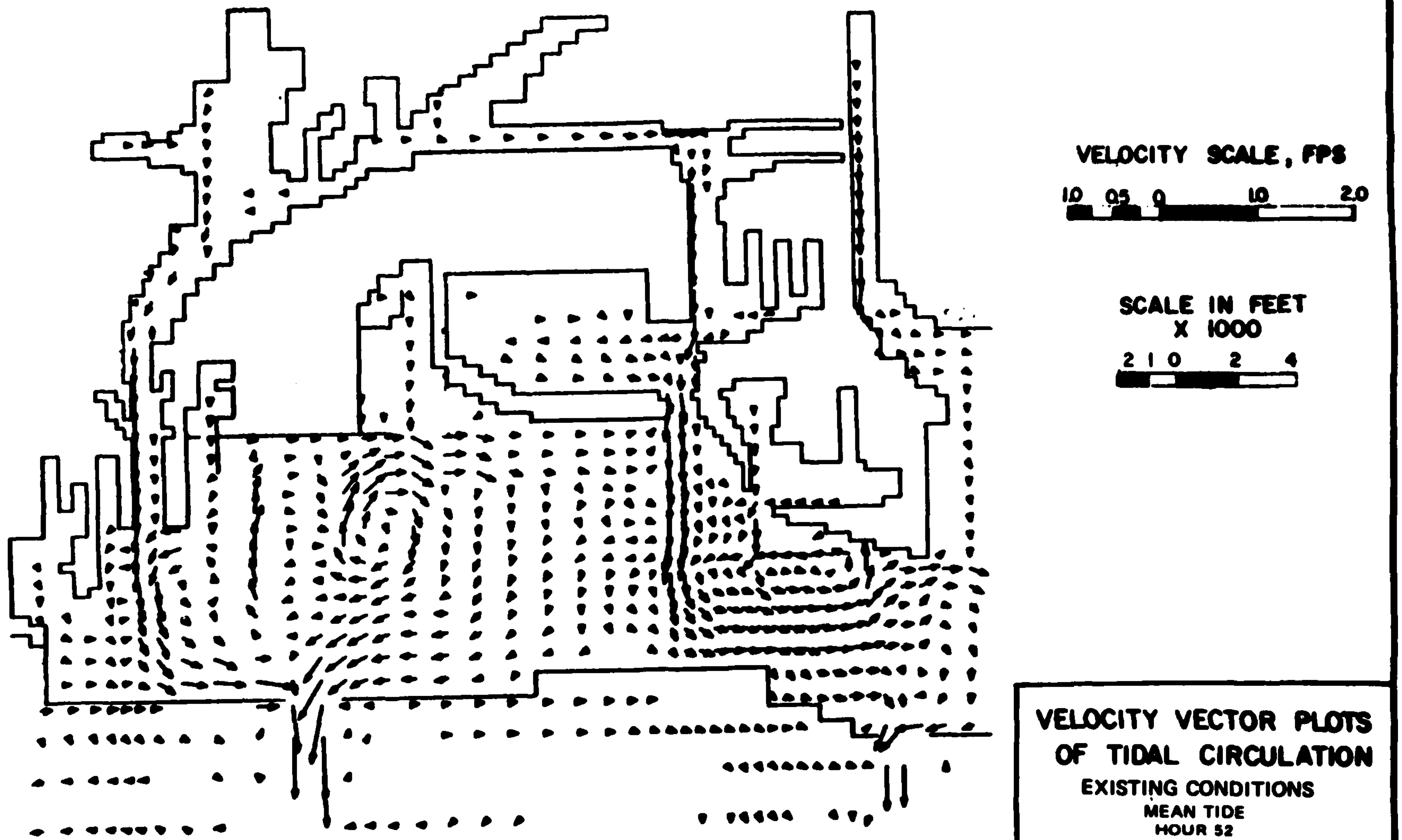

VELOCITY VECTOR PLOTS
OF TIDAL CIRCULATION
EXISTING CONDITIONS
SPRING TIDE
HOUR 64
VELOCITY SCALE, FPS
1.0 0.5 0 1.0 2.0
SCALE IN FEET
X 1000
2 1 0 2 4

PLATE 74

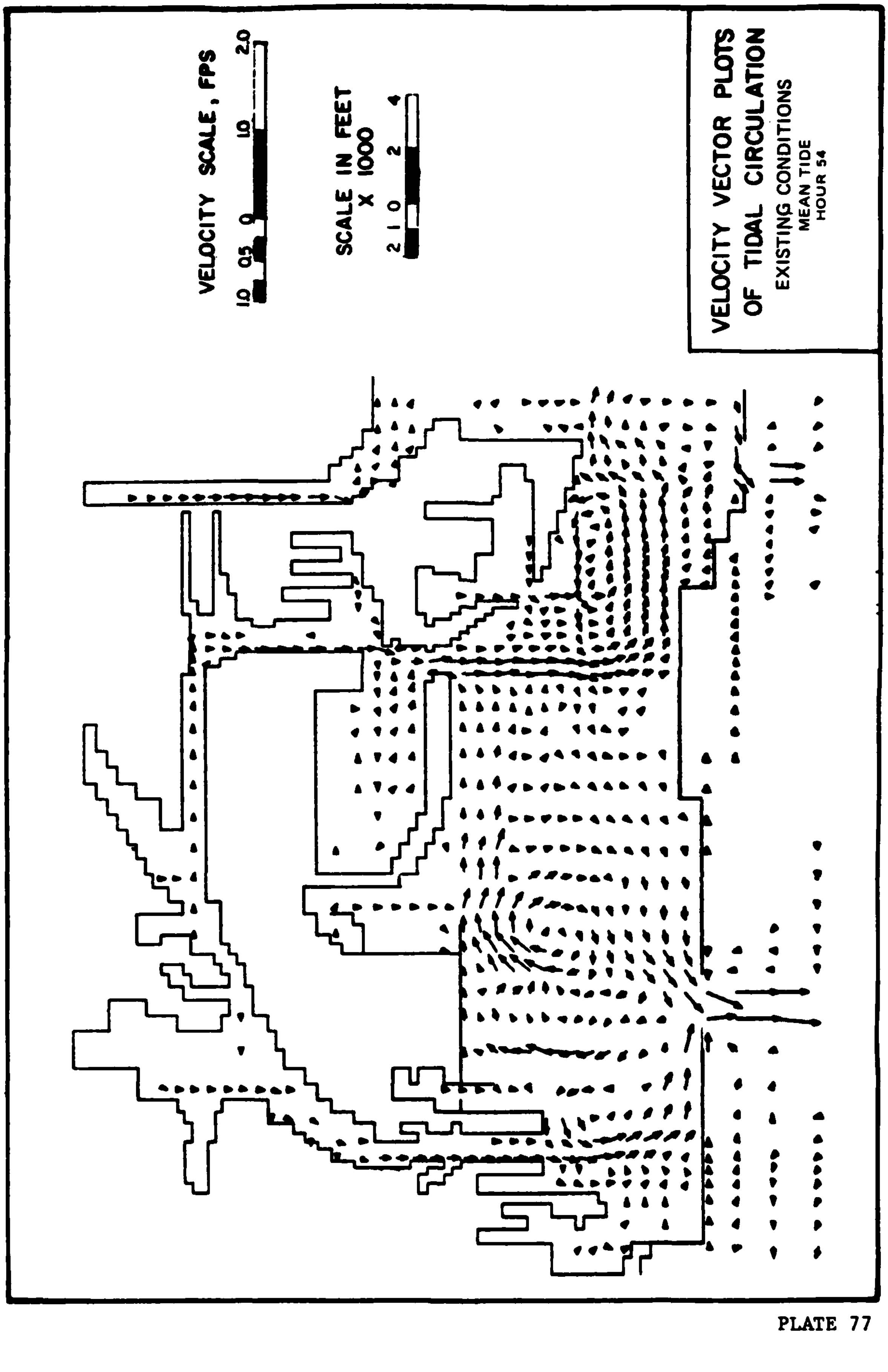


VELOCITY VECTOR PLOTS
OF TIDAL CIRCULATION
EXISTING CONDITIONS
SPRING TIDE
HOUR 66



VELOCITY VECTOR PLOTS OF TIDAL CIRCULATION
EXISTING CONDITIONS
MEAN TIDE
HOUR 52

PLATE 76


VELOCITY SCALE, FPS
1.0 0.5 0 1.0 2.0
SCALE IN FEET
X 1000
2 1 0 2 4
VELOCITY VECTOR PLOTS
OF TIDAL CIRCULATION
EXISTING CONDITIONS
MEAN TIDE
HOUR 54

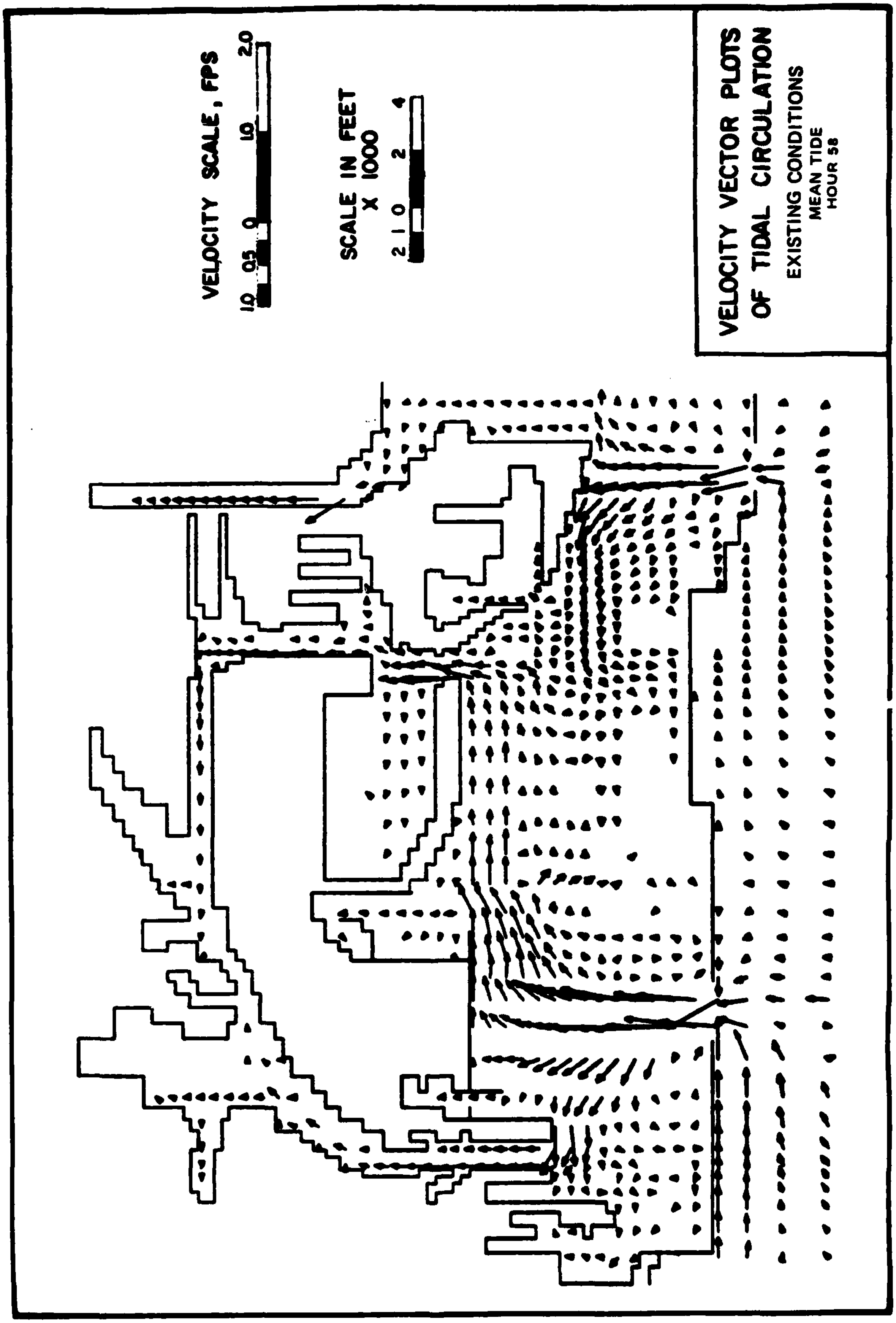
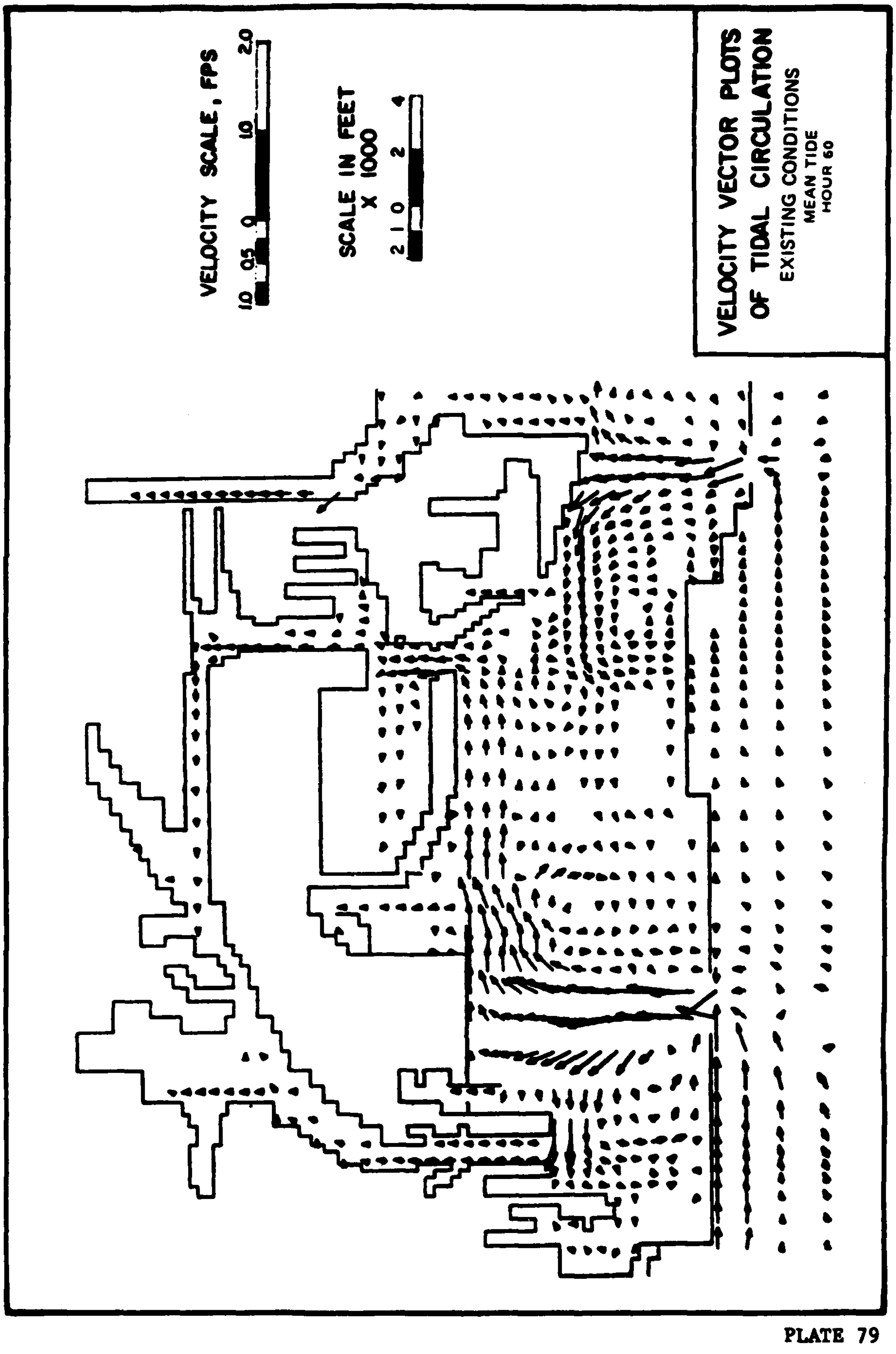
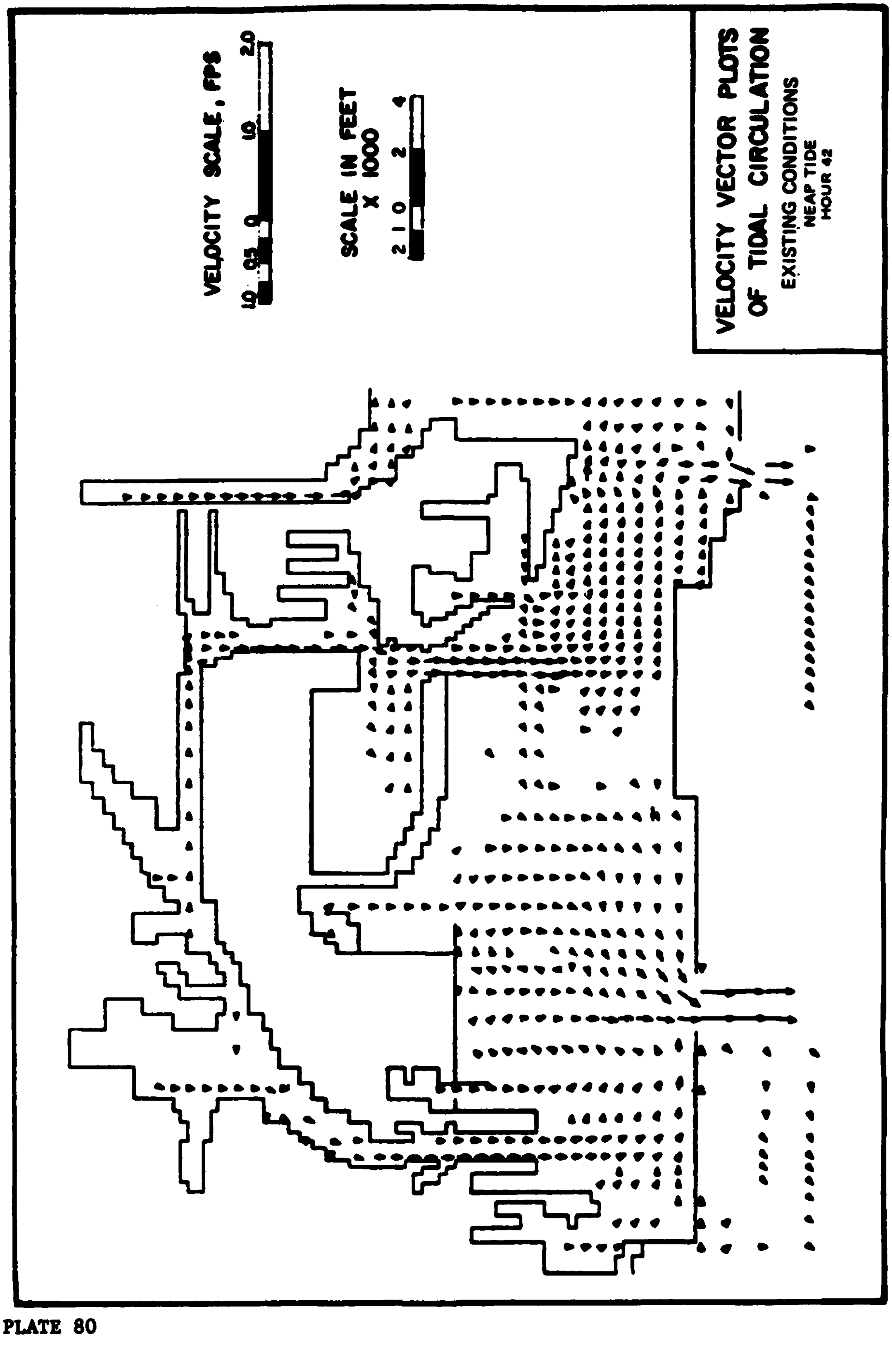

VELOCITY SCALE, FPS
1.0 0.5 0 1.0 2.0
SCALE IN FEET
X 1000
2 1 0 2 4
VELOCITY VECTOR PLOTS
OF TIDAL CIRCULATION
EXISTING CONDITIONS
MEAN TIDE
HOUR 58

PLATE 78



VELOCITY SCALE, FPS
1.0 0.5 0 1.0 2.0
SCALE IN FEET X 1000
2 1 0 2 4
VELOCITY VECTOR PLOTS OF TIDAL CIRCULATION
EXISTING CONDITIONS
MEAN TIDE
HOUR 60


VELOCITY SCALE, FPS
1.0 0.5 0 1.0 2.0
SCALE IN FEET X 1000
2 1 0 2 4
VELOCITY VECTOR PLOTS OF TIDAL CIRCULATION
EXISTING CONDITIONS
NEAP TIDE
HOUR 42

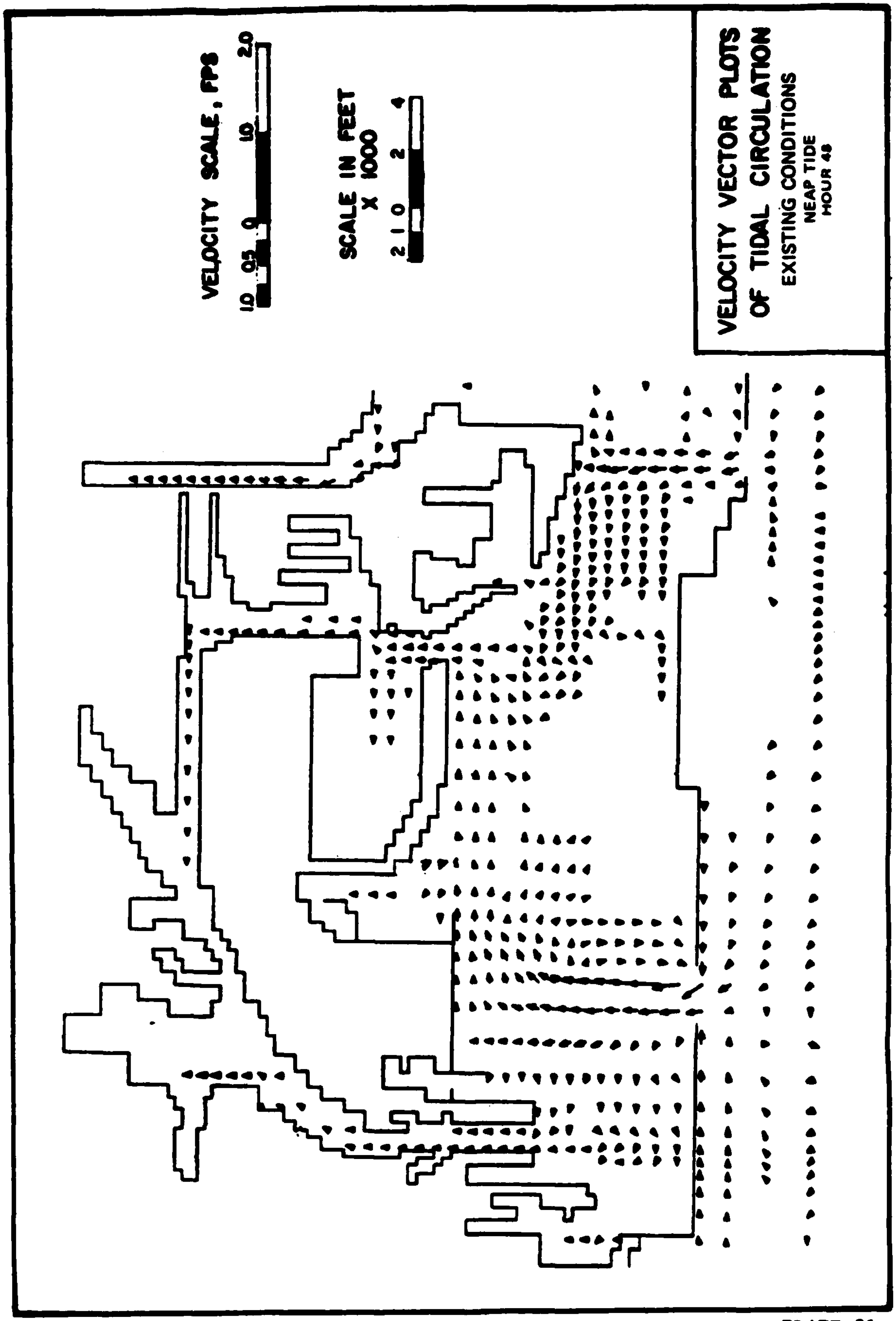

VELOCITY SCALE, FPS
1.0 0.5 0 1.0 2.0
SCALE IN FEET X 1000
2 1 0 2 4
VELOCITY VECTOR PLOTS
OF TIDAL CIRCULATION
EXISTING CONDITIONS
NEAP TIDE
HOUR 48

PLATE 81

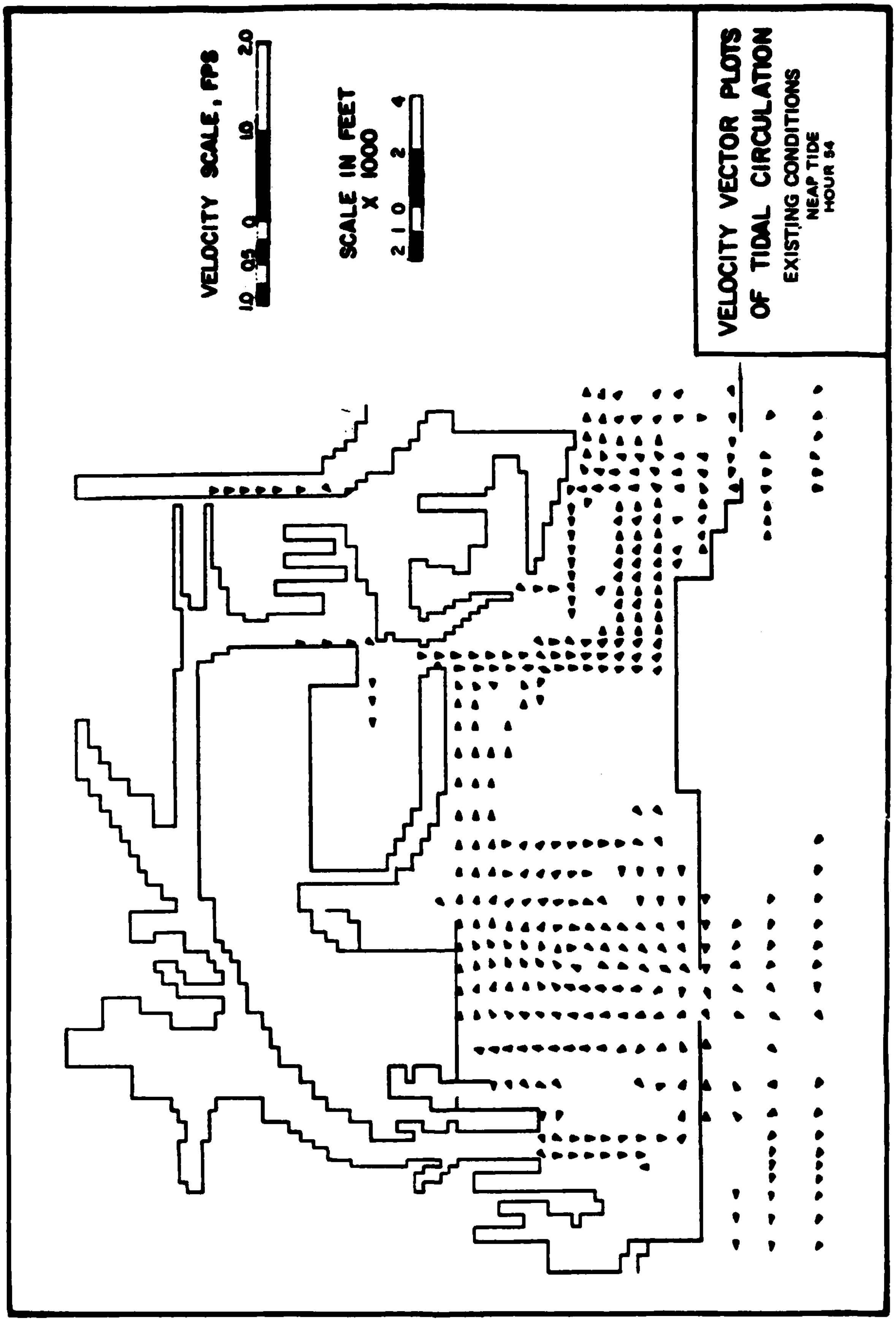
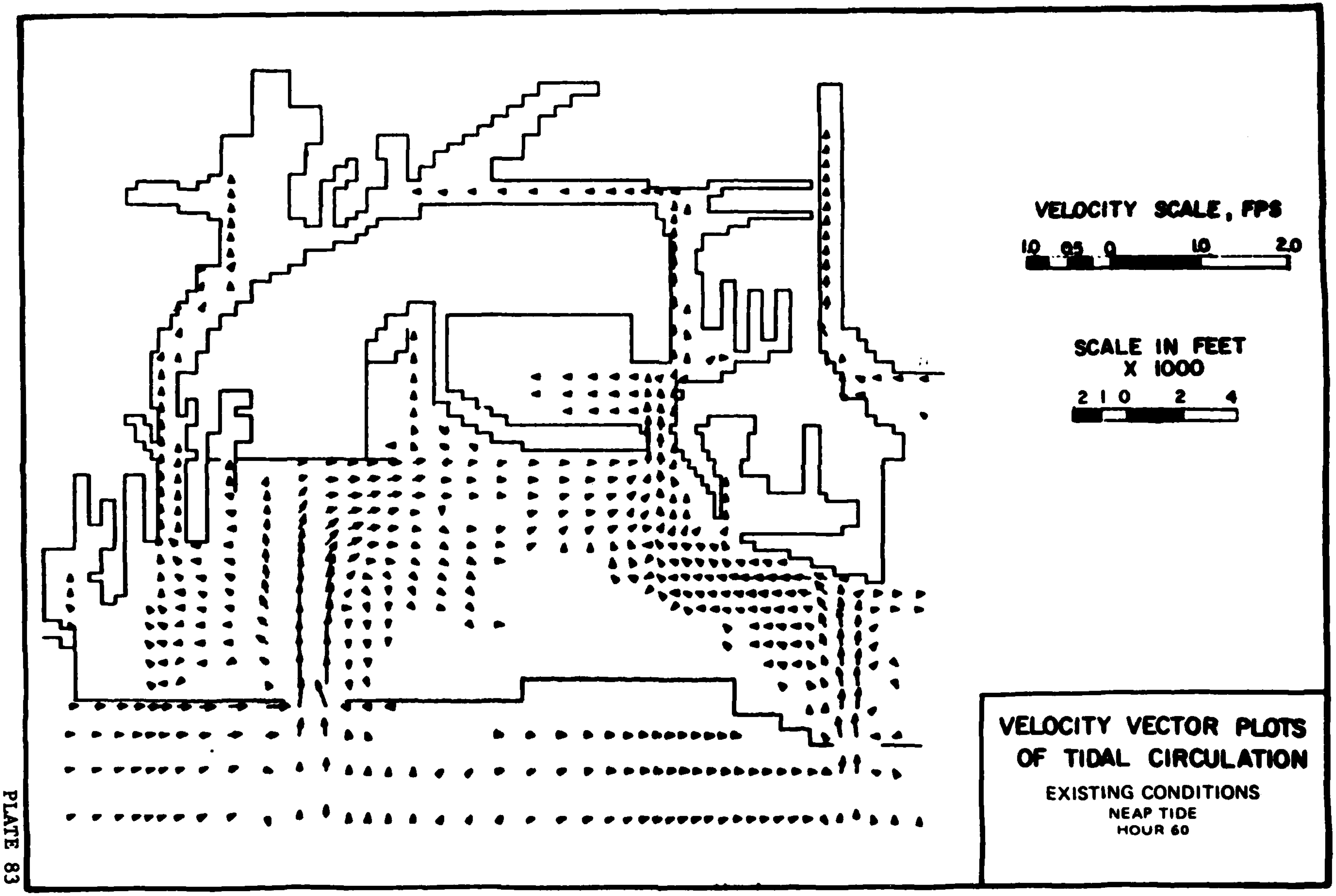
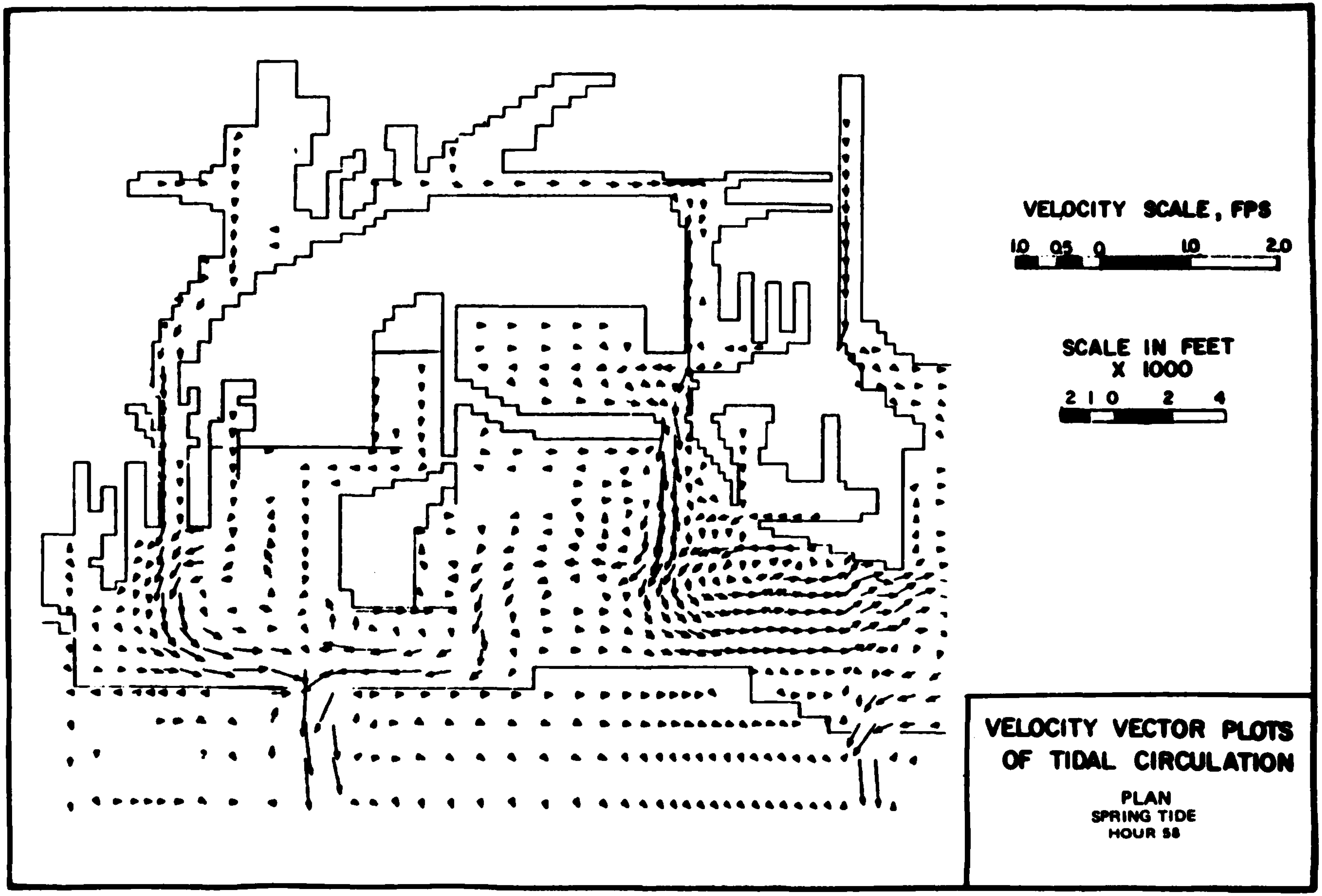

VELOCITY SCALE, FPS
1.0 0.5 0 1.0 2.0
SCALE IN FEET X 1000
2 1 0 2 4
VELOCITY VECTOR PLOTS
OF TIDAL CIRCULATION
EXISTING CONDITIONS
NEAP TIDE
HOUR 54

PLATE 82

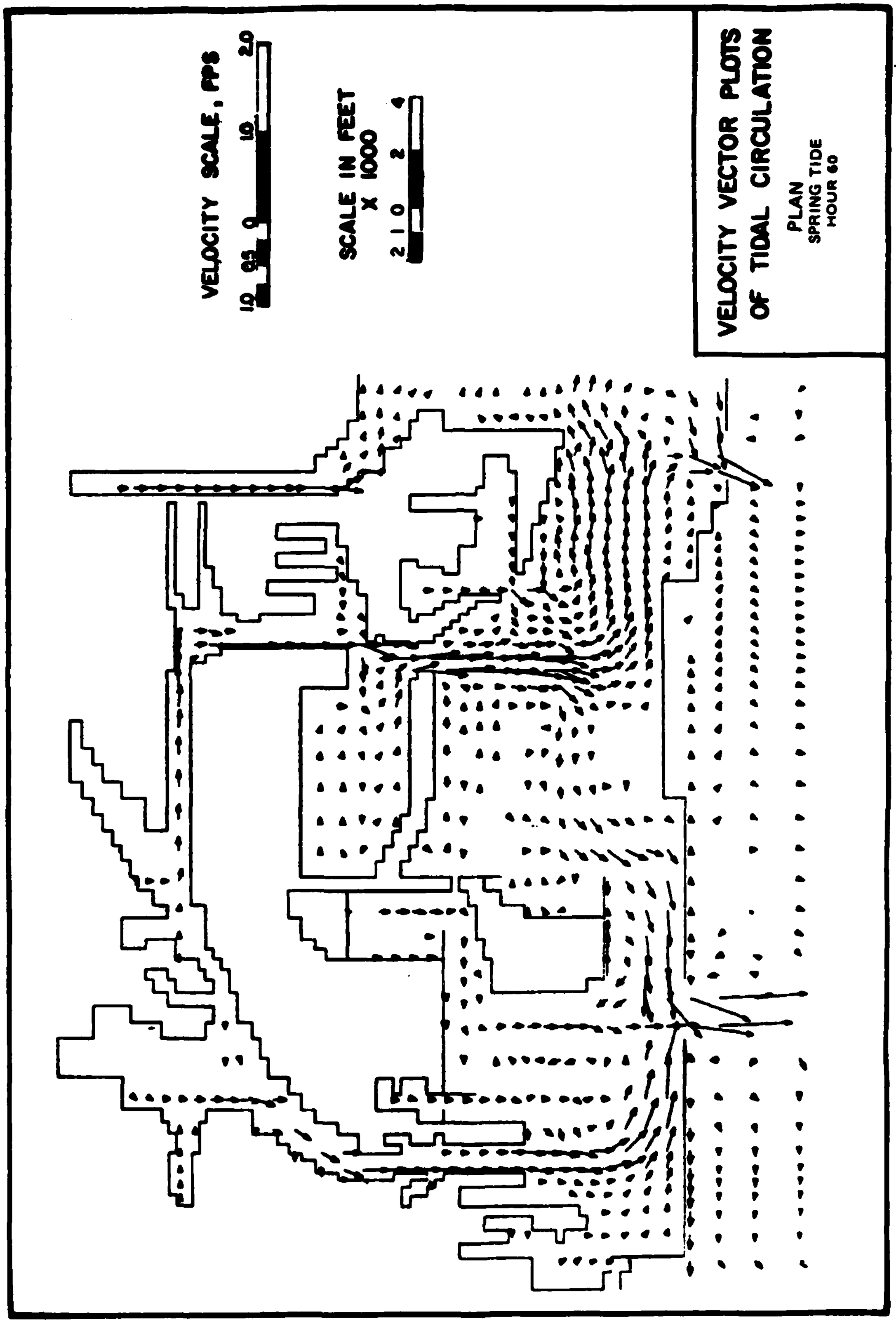


VELOCITY VECTOR PLOTS
OF TIDAL CIRCULATION
EXISTING CONDITIONS
NEAP TIDE
HOUR 60

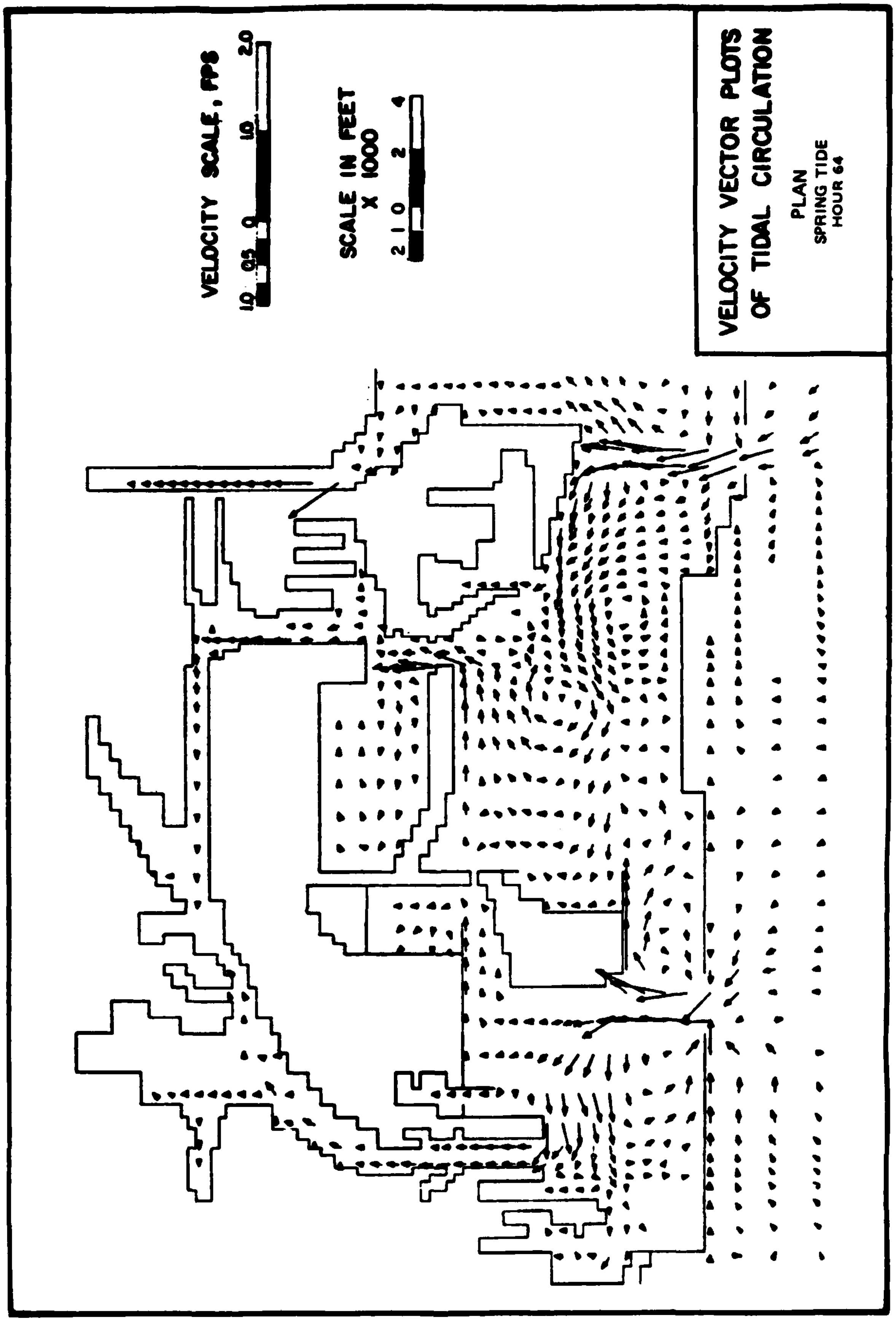


VELOCITY VECTOR PLOTS OF TIDAL CIRCULATION

PLAN
SPRING TIDE
HOUR 58



VELOCITY SCALE, FPS
1.0 0.5 0 1.0 2.0
SCALE IN FEET
X 1000
2 1 0 2 4
VELOCITY VECTOR PLOTS
OF TIDAL CIRCULATION
PLAN
SPRING TIDE
HOUR 60


VELOCITY SCALE, FPS
1.0 0.5 0 1.0 2.0
SCALE IN FEET
X 1000
2 1 0 2 4
VELOCITY VECTOR PLOTS
OF TIDAL CIRCULATION
PLAN
SPRING TIDE
HOUR 64

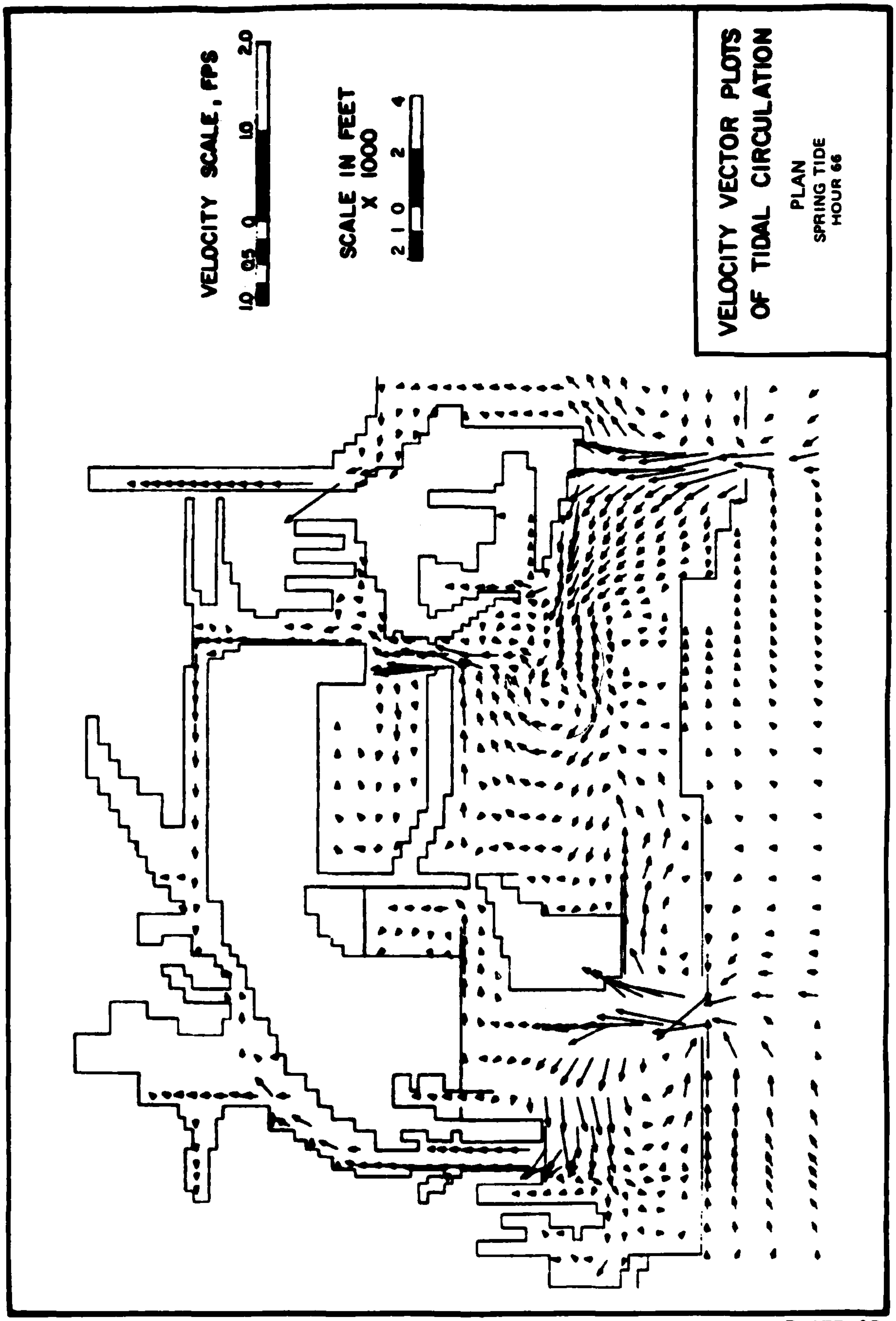
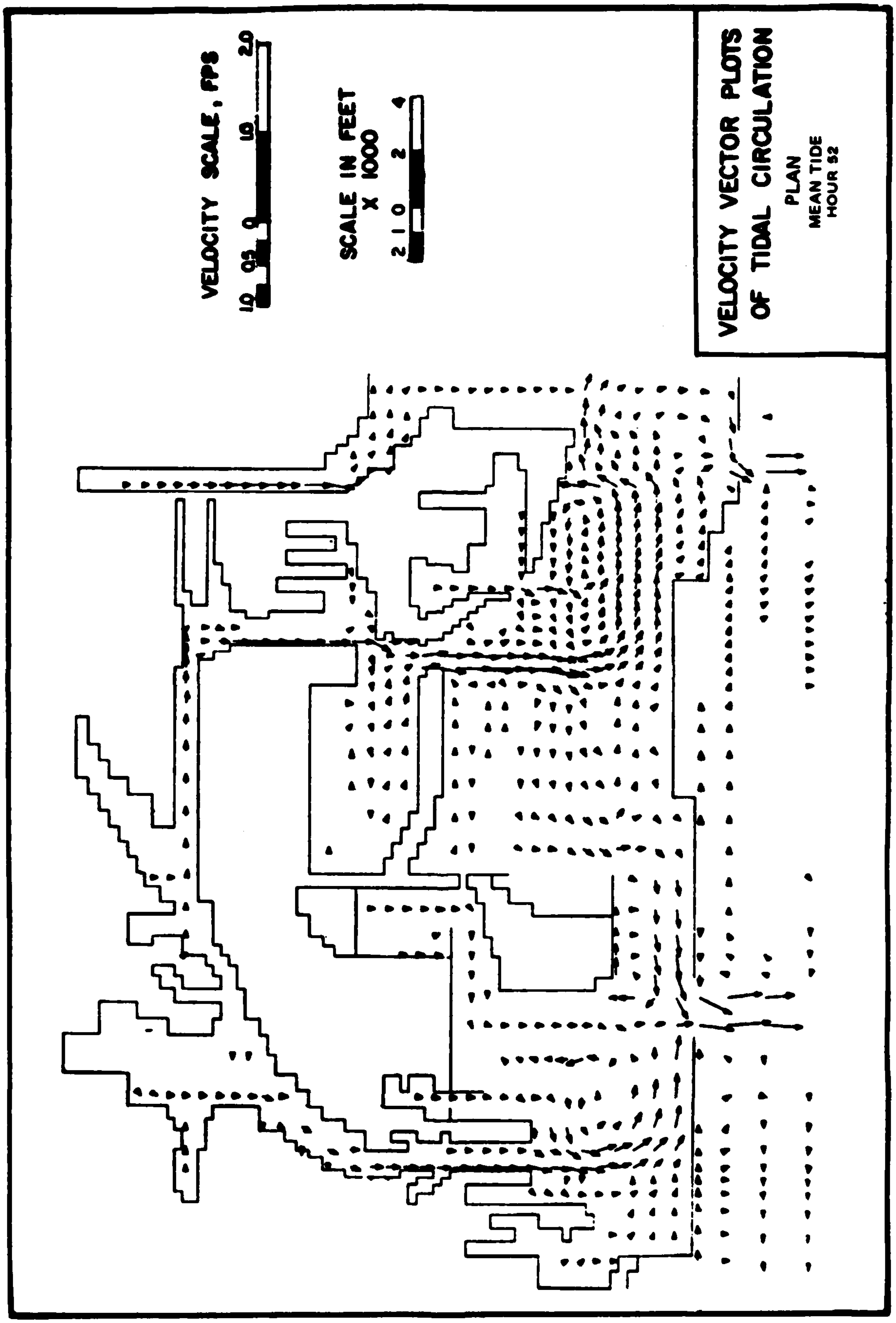
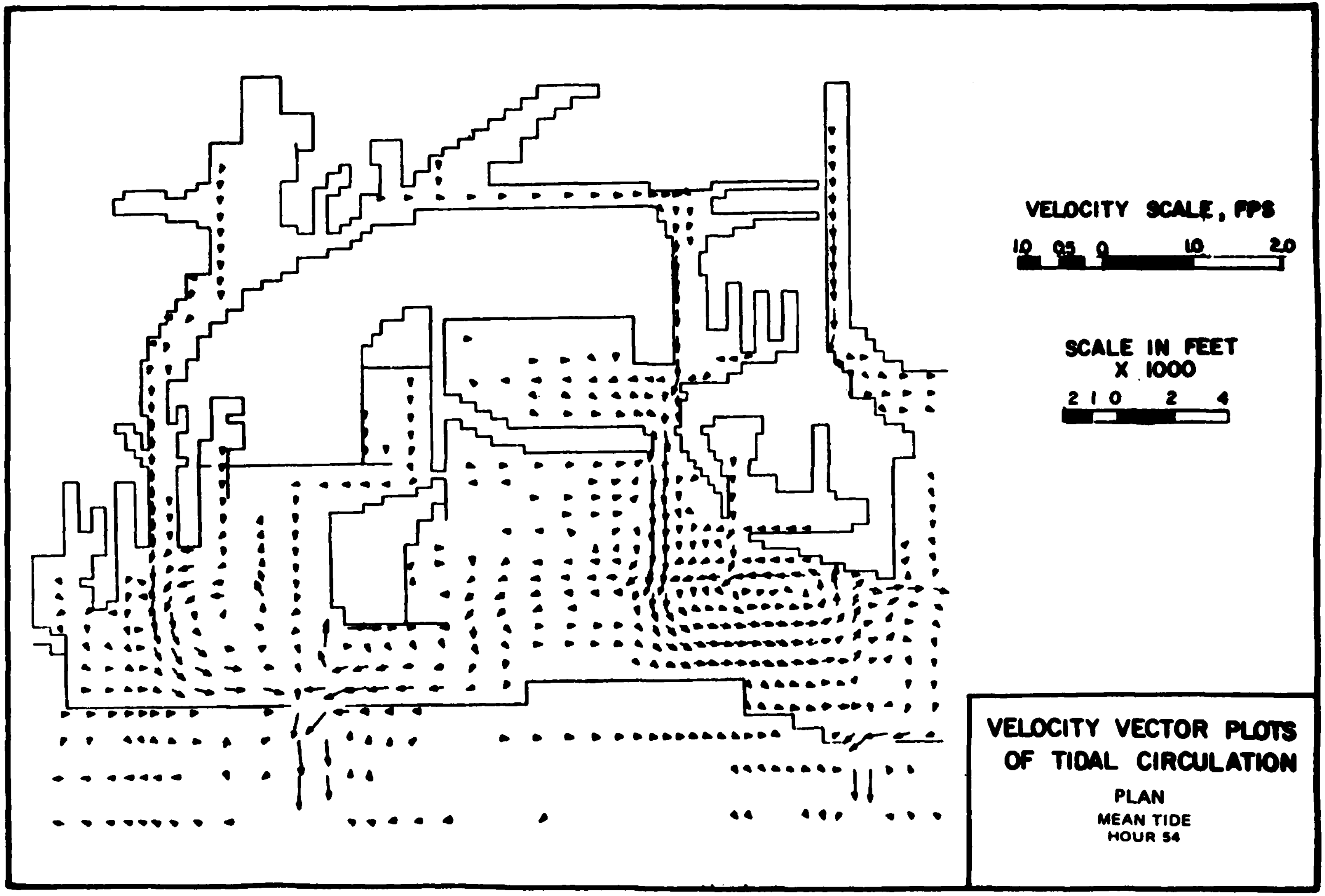

VELOCITY VECTOR PLOTS
OF TIDAL CIRCULATION
PLAN
SPRING TIDE
HOUR 66
VELOCITY SCALE, FPS
1.0 0.5 0 1.0 2.0
SCALE IN FEET
X 1000
2 1 0 2 4

PLATE 87



VELOCITY VECTOR PLOTS
OF TIDAL CIRCULATION
PLAN
MEAN TIDE
HOUR 52
VELOCITY SCALE, FPS
1.0 0.5 0 1.0 2.0
SCALE IN FEET
X 1000
2 1 0 2 4

PLATE 88



VELOCITY SCALE, FPS
1.0 0.5 0 1.0 2.0
SCALE IN FEET X 1000
2 1 0 2 4
VELOCITY VECTOR PLOTS
OF TIDAL CIRCULATION
PLAN
MEAN TIDE
HOUR 54

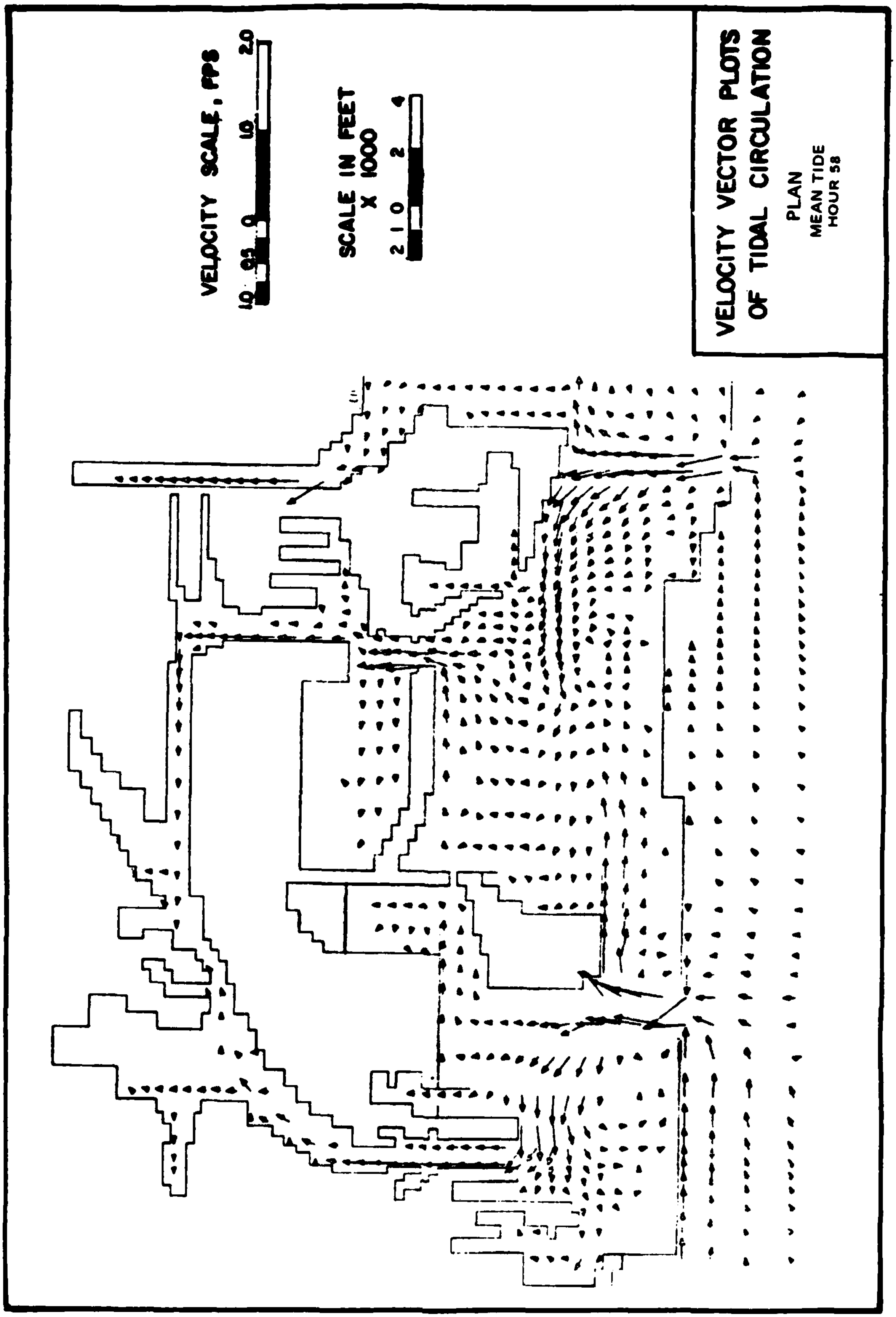
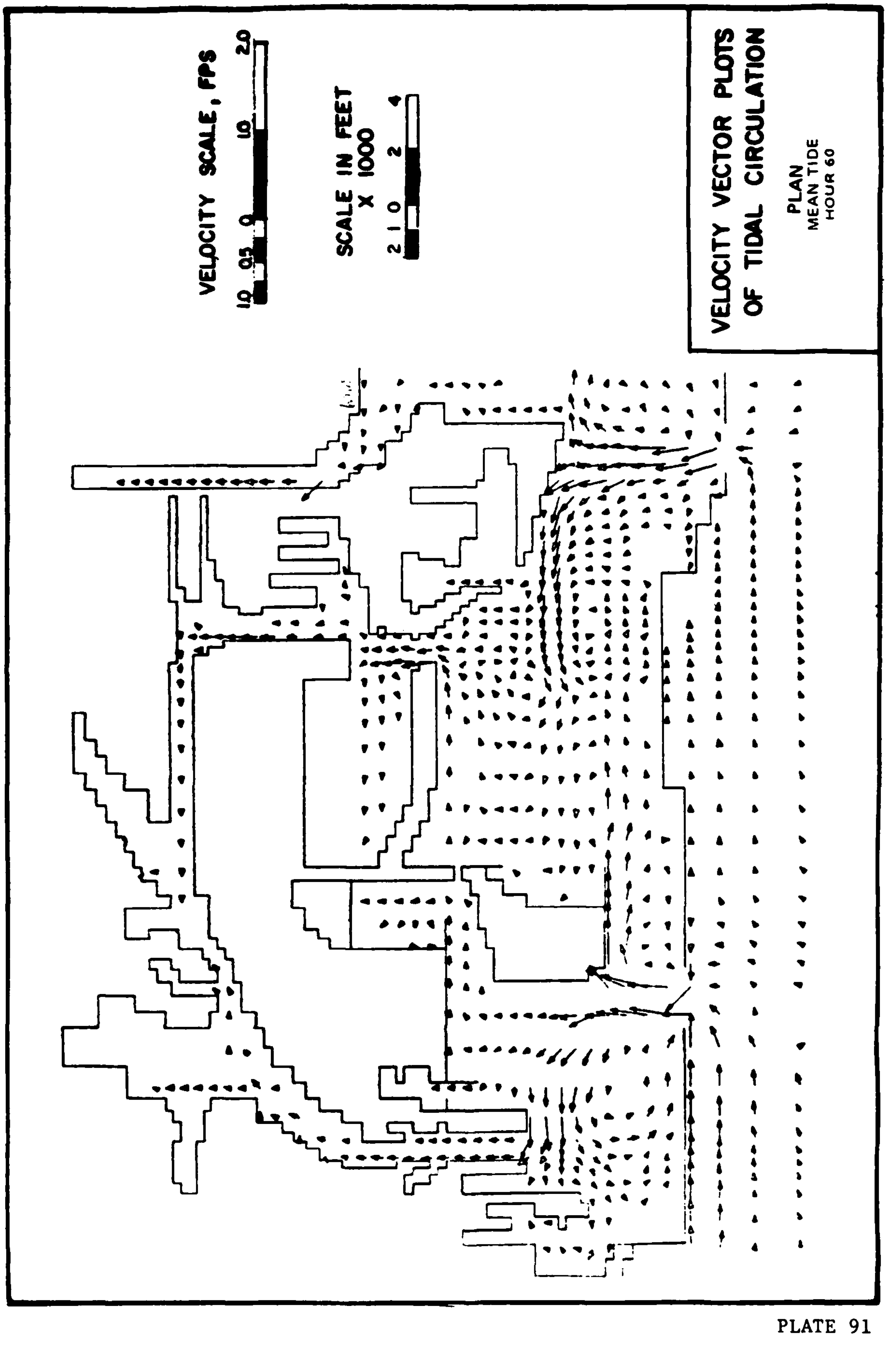

VELOCITY SCALE, FPS
1.0 0.5 0 1.0 2.0
SCALE IN FEET X 1000
2 1 0 2 4
VELOCITY VECTOR PLOTS OF TIDAL CIRCULATION
PLAN
MEAN TIDE
HOUR 58

PLATE 90


VELOCITY VECTOR PLOTS
OF TIDAL CIRCULATION
PLAN
MEAN TIDE
HOUR 60
VELOCITY SCALE, FPS
1.0 0.5 0 1.0 2.0
SCALE IN FEET
X 1000
2 1 0 2 4

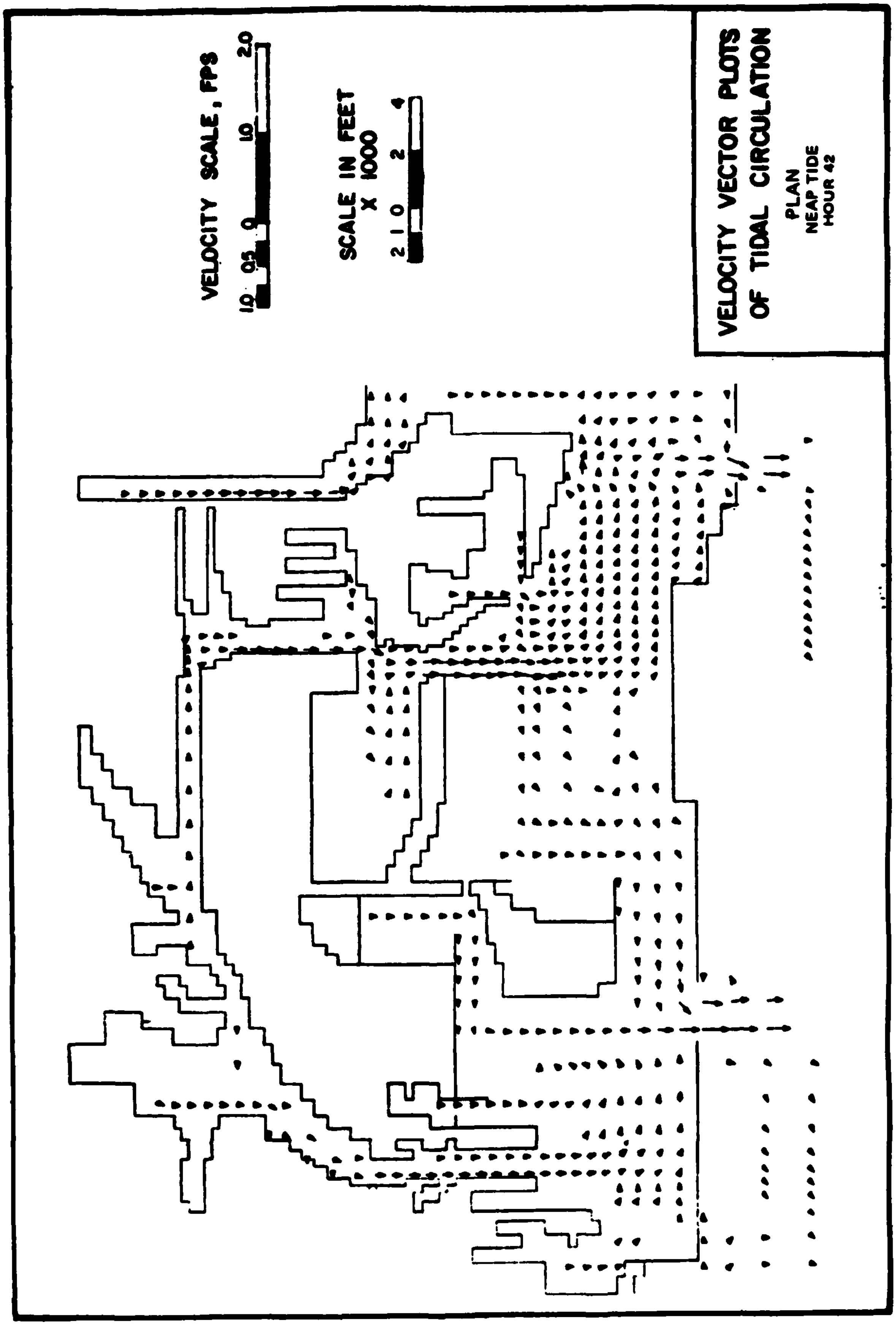
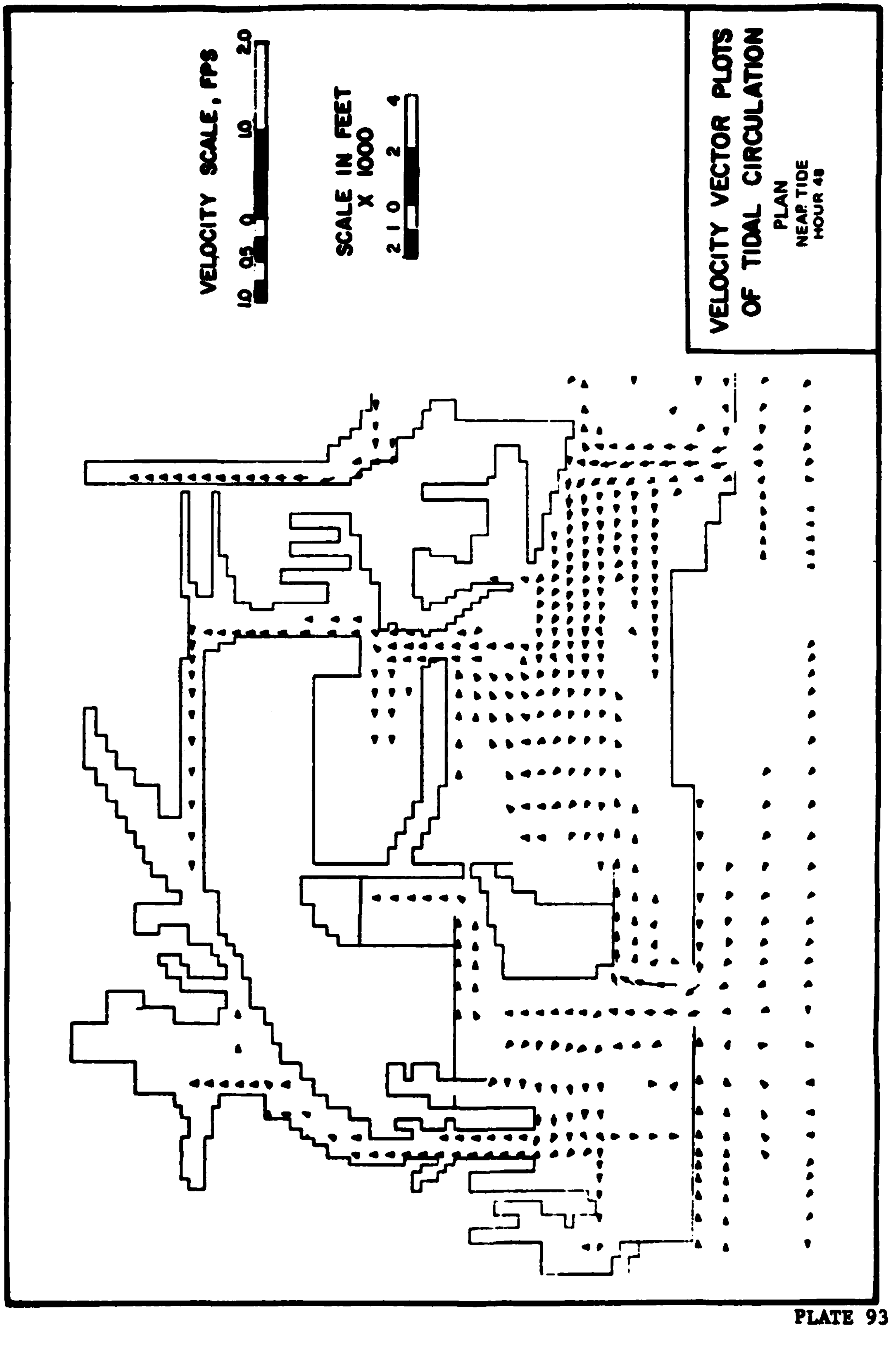
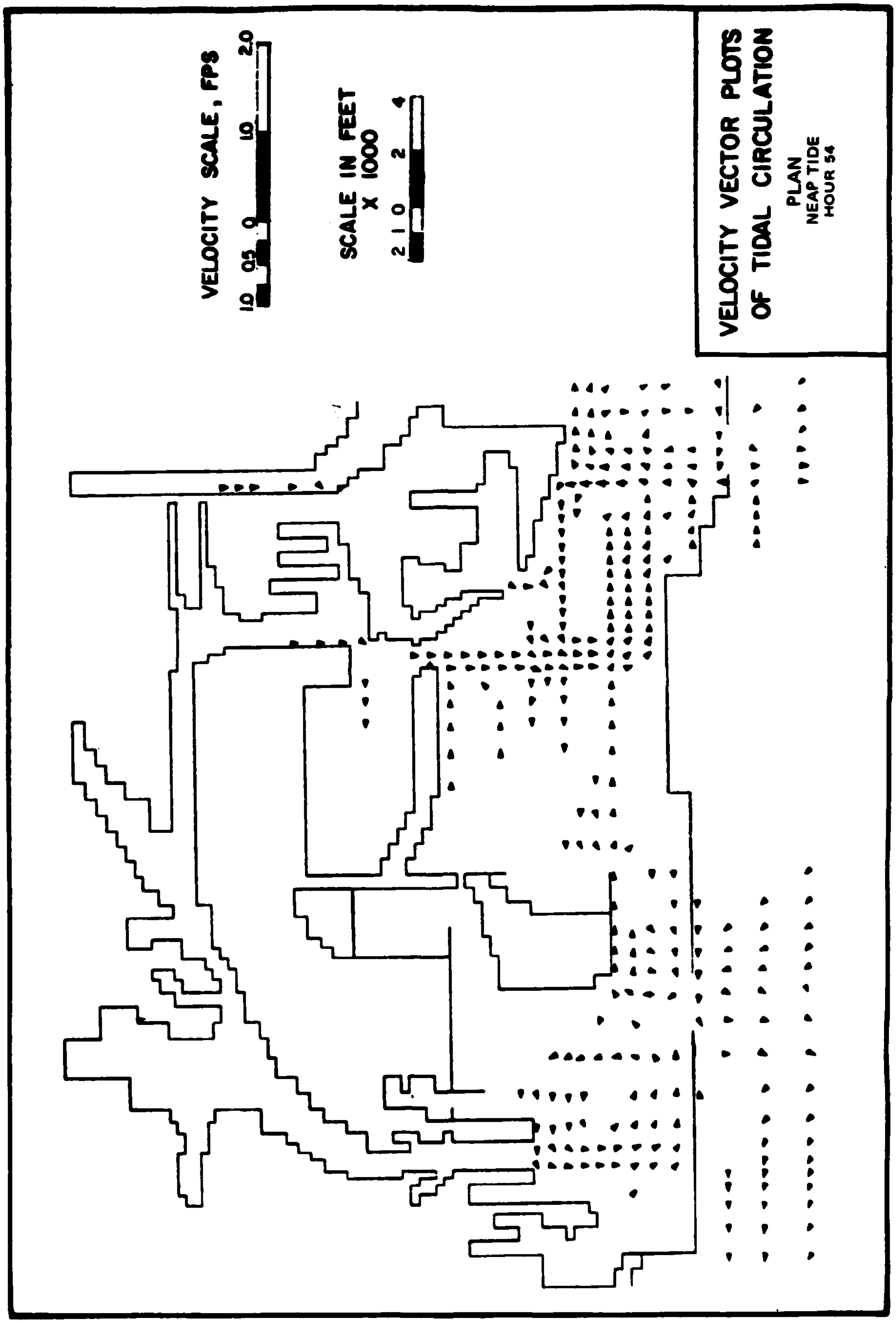

VELOCITY SCALE, FPS
1.0 0.5 0 1.0 2.0
SCALE IN FEET X 1000
2 1 0 2 4
VELOCITY VECTOR PLOTS OF TIDAL CIRCULATION
PLAN
NEAP TIDE
HOUR 42

PLATE 92



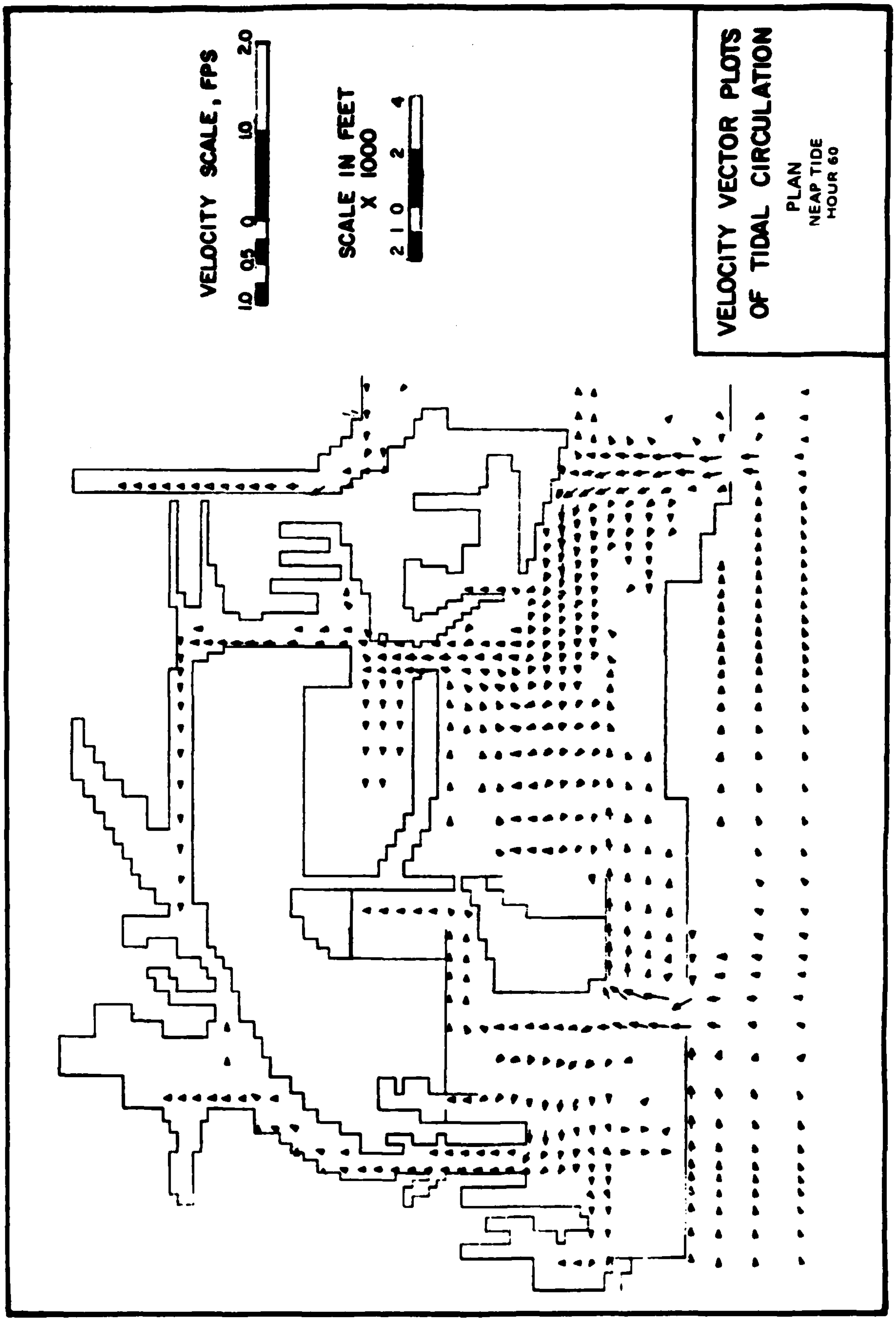
VELOCITY SCALE, FPS
1.0 0.5 0 1.0 2.0
SCALE IN FEET X 1000
2 1 0 2 4
VELOCITY VECTOR PLOTS
OF TIDAL CIRCULATION
PLAN
NEAP TIDE
HOUR 48

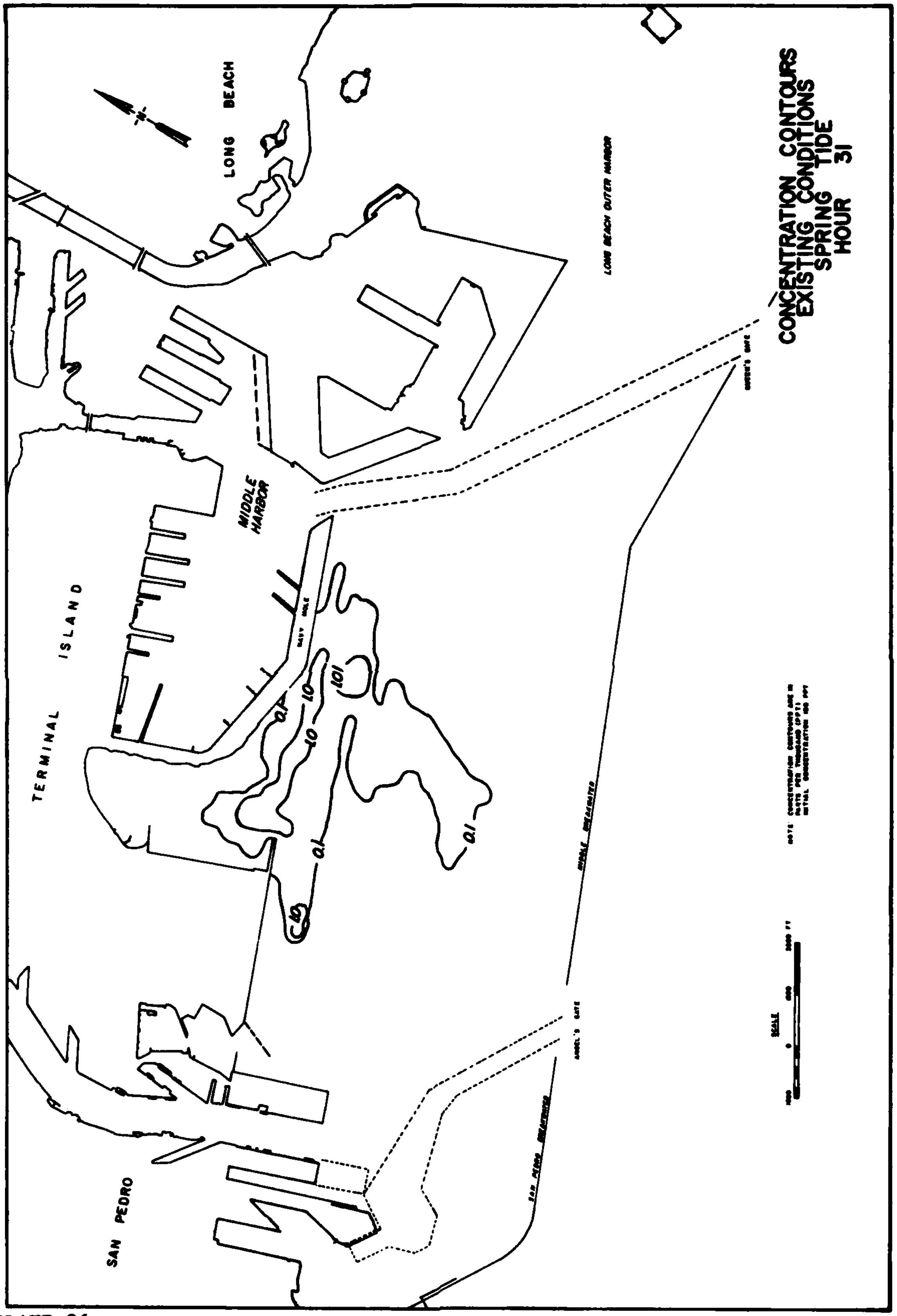
PLATE 93



VELOCITY SCALE, FPS
1.0 0.5 0 1.0 2.0
SCALE IN FEET
X 1000
2 1 0 2 4
VELOCITY VECTOR PLOTS
OF TIDAL CIRCULATION
PLAN
NEAP TIDE
HOUR 54

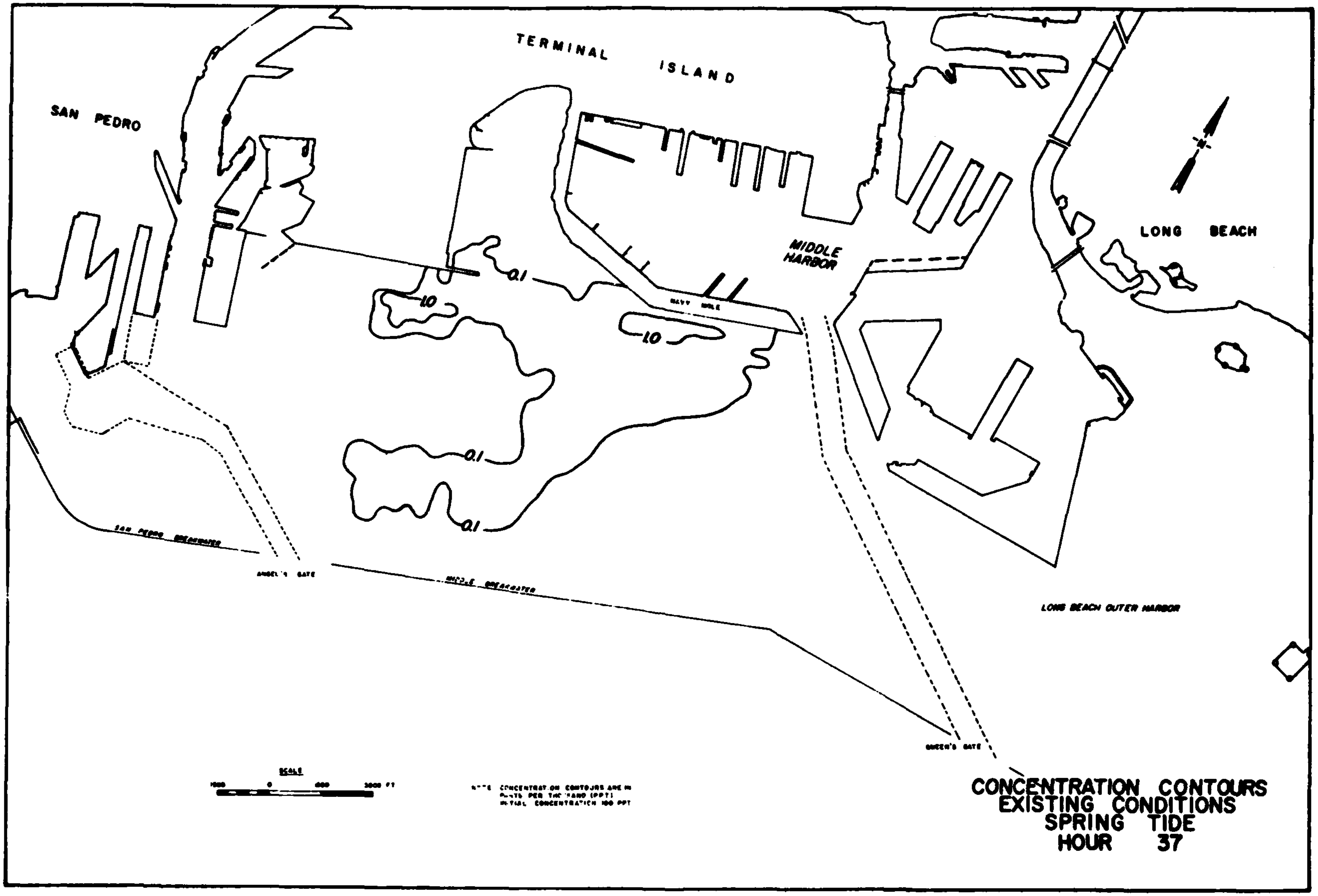
PLATE 94


VELOCITY VECTOR PLOTS
OF TIDAL CIRCULATION
PLAN
NEAP TIDE
HOUR 60
VELOCITY SCALE, FPS
1.0 0.5 0 1.0 2.0
SCALE IN FEET
X 1000
2 1 0 2 4



CONCENTRATION CONTOURS
EXISTING CONDITIONS
SPRING TIDE
HOUR 31
LONG BEACH
LONG BEACH OUTER HARBOR
MIDDLE HARBOR
TERMINAL ISLAND
SAN PEDRO
NAVY MOLE
MIDDLE BREAKWATER
SAN PEDRO BREAKWATER
0.1
1.0
10
0.1
1.0
0.1
0.1
10
SCALE

PLATE 96



TERMINAL ISLAND
SAN PEDRO
LONG BEACH
MIDDLE HARBOR
NAVY MOLE
0.1
1.0
1.0
0.1
0.1
SAN PEDRO BREAKWATER
ANGEL'S GATE
MIDDLE BREAKWATER
LONG BEACH OUTER HARBOR
QUEEN'S GATE
SCALE
CONCENTRATION CONTOURS
EXISTING CONDITIONS
SPRING TIDE
HOUR 37

PLATE 97

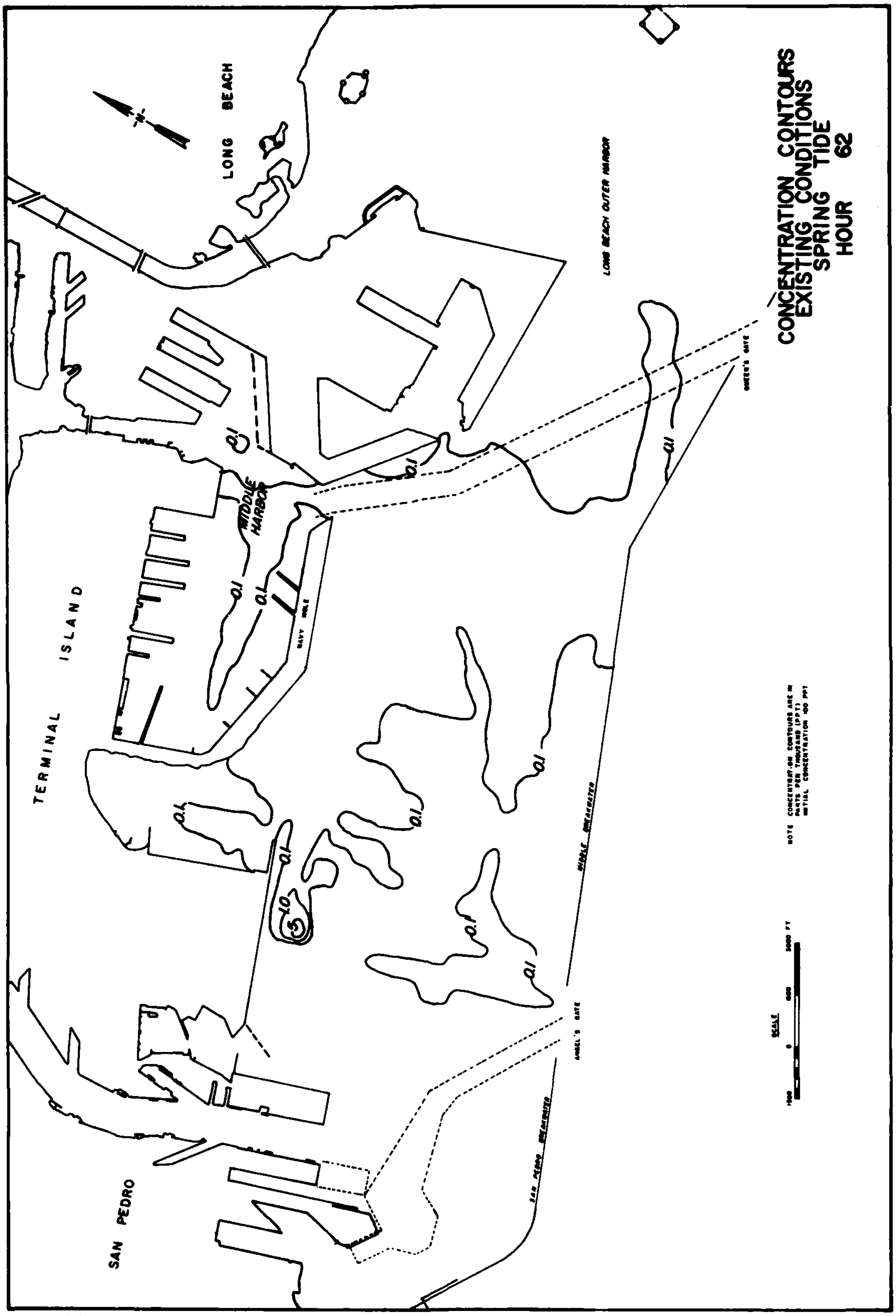
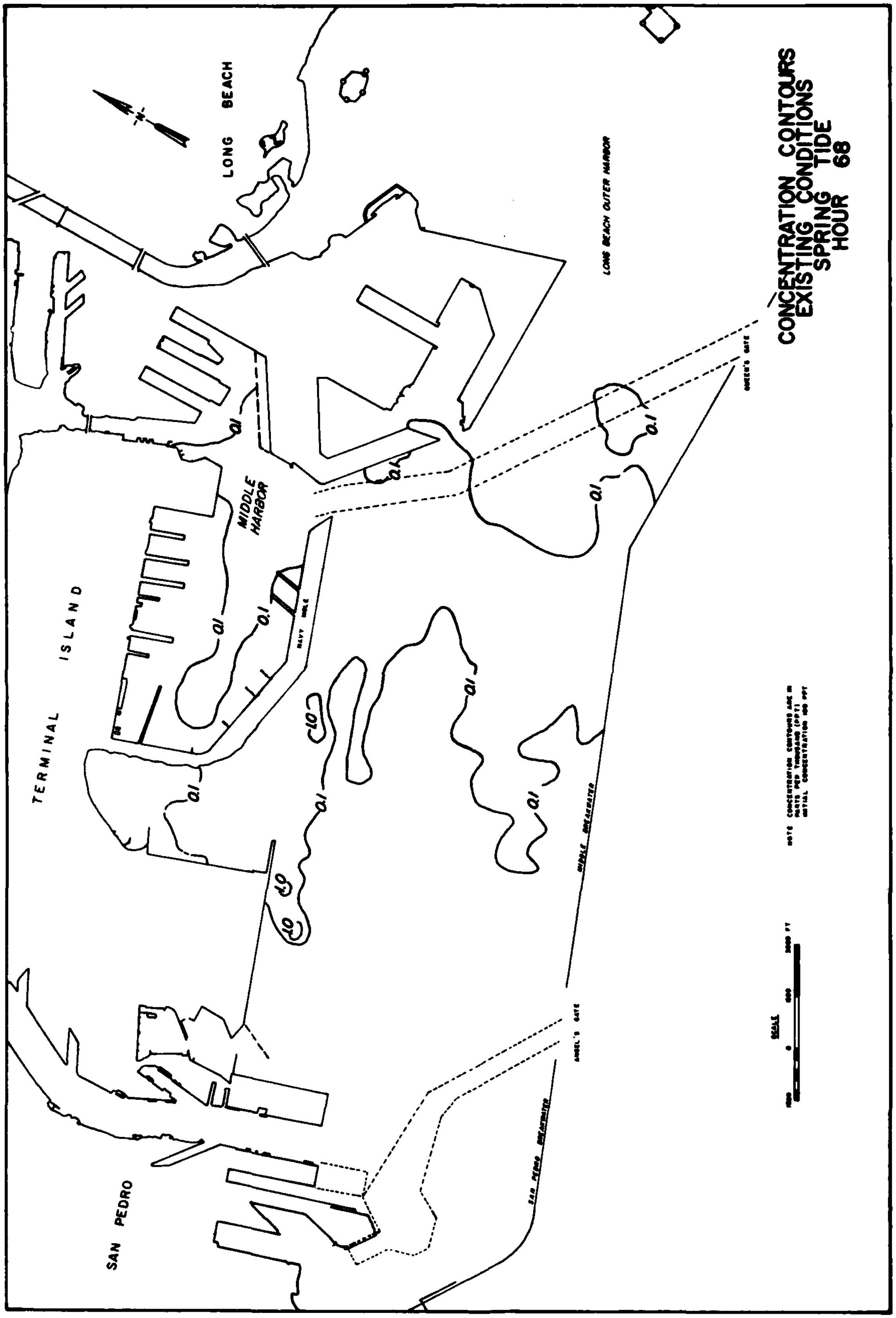

CONCENTRATION CONTOURS
EXISTING CONDITIONS
SPRING TIDE
HOUR 62
LONG BEACH
LONG BEACH OUTER HARBOR
TERMINAL ISLAND
SAN PEDRO
MIDDLE HARBOR
NAVY MOLE
QUEEN'S GATE
ANGEL'S GATE
MIDDLE BREAKWATER
SAN PEDRO BREAKWATER
NOTE CONCENTRATION CONTOURS ARE IN PARTS PER THOUSAND (PPT) INITIAL CONCENTRATION 100 PPT
SCALE
1000 0 1000 2000 FT
0.1
1.0

PLATE 98



CONCENTRATION CONTOURS
EXISTING CONDITIONS
SPRING TIDE
HOUR 68
LONG BEACH
LONG BEACH OUTER HARBOR
MIDDLE HARBOR
TERMINAL ISLAND
SAN PEDRO
NAVY MOLE
MIDDLE BREAKWATER
SAN PEDRO BREAKWATER
QUEEN'S GATE
ANGEL'S GATE
0.1
NOTE CONCENTRATION CONTOURS ARE IN PARTS PER THOUSAND (PPT)
INITIAL CONCENTRATION 100 PPT
SCALE

PLATE 99

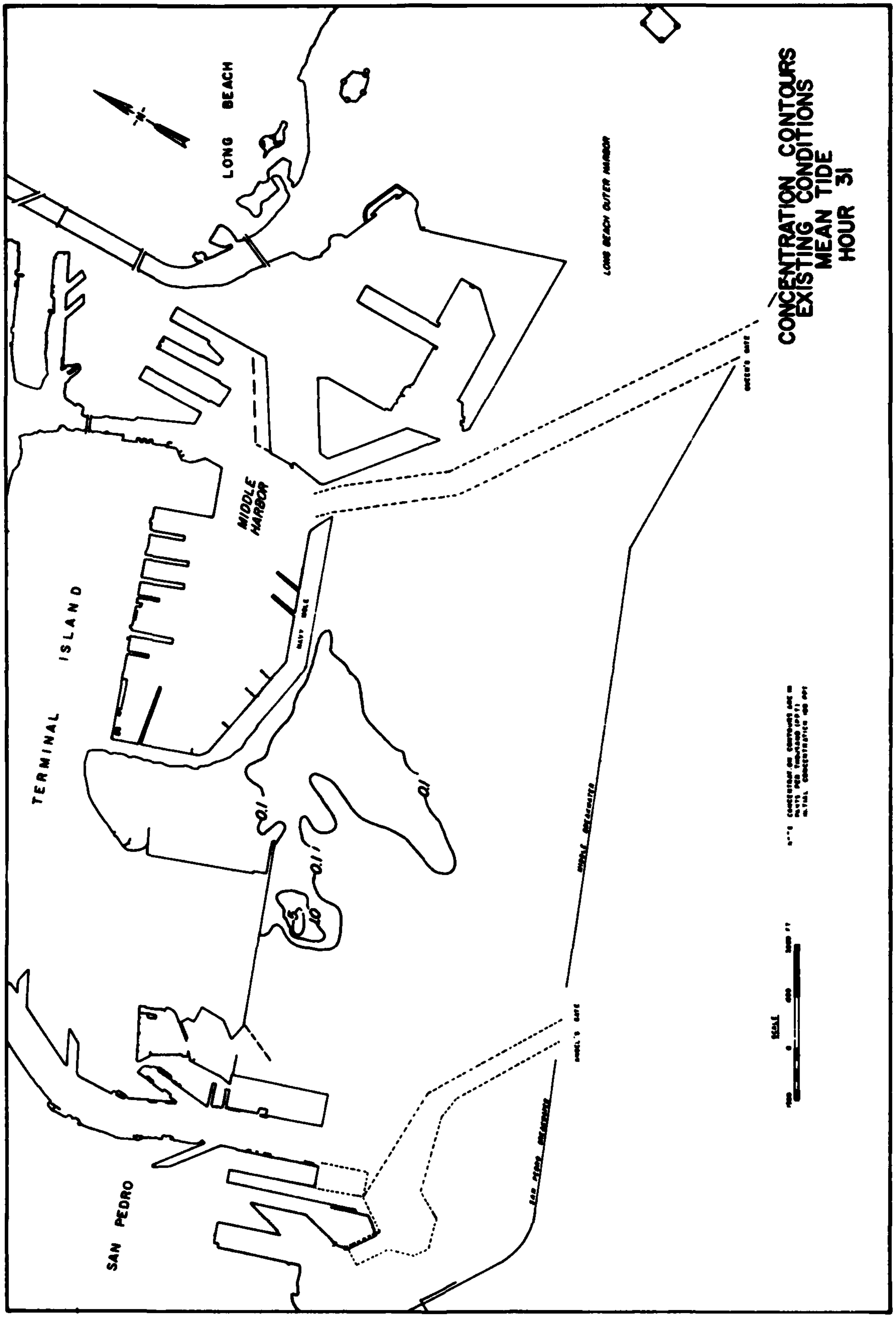
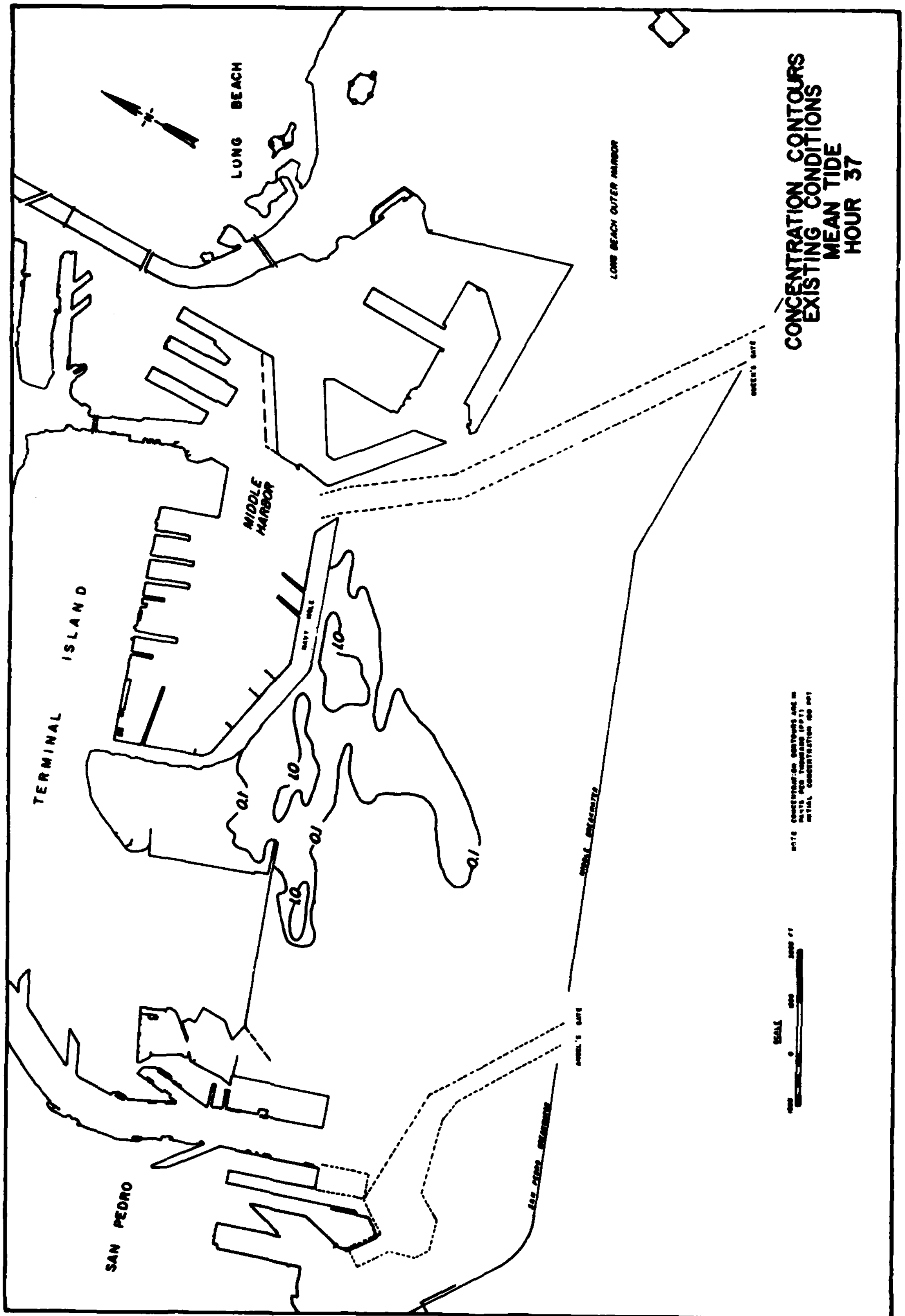

CONCENTRATION CONTOURS
EXISTING CONDITIONS
MEAN TIDE
HOUR 31
LONG BEACH
LONG BEACH OUTER HARBOR
MIDDLE HARBOR
TERMINAL ISLAND
SAN PEDRO
0.1
1.0

PLATE 100


CONCENTRATION CONTOURS
EXISTING CONDITIONS
MEAN TIDE
HOUR 37
LONG BEACH
LONG BEACH OUTER HARBOR
MIDDLE HARBOR
TERMINAL ISLAND
NAVY MOLE
SAN PEDRO
1.0
0.1

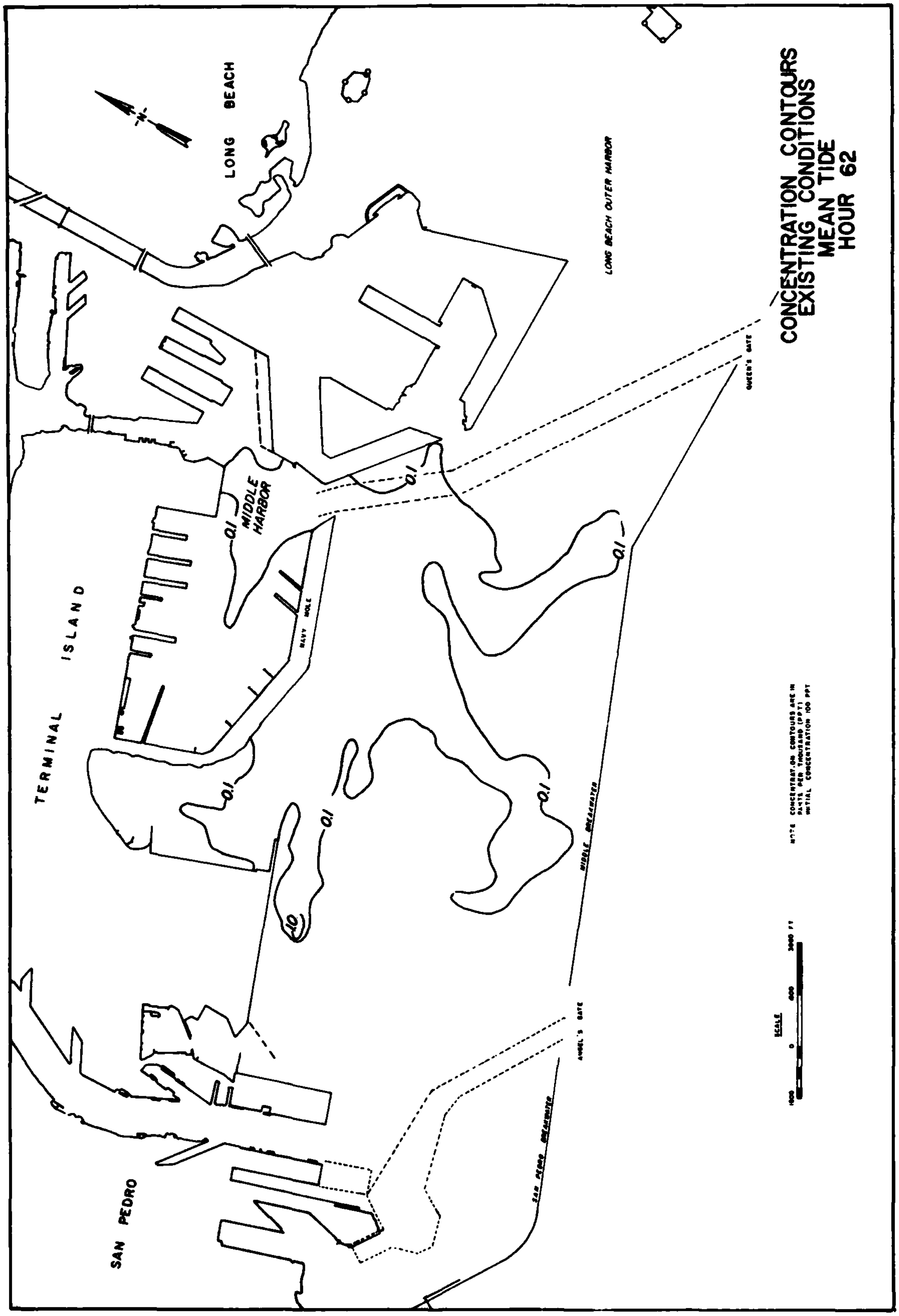
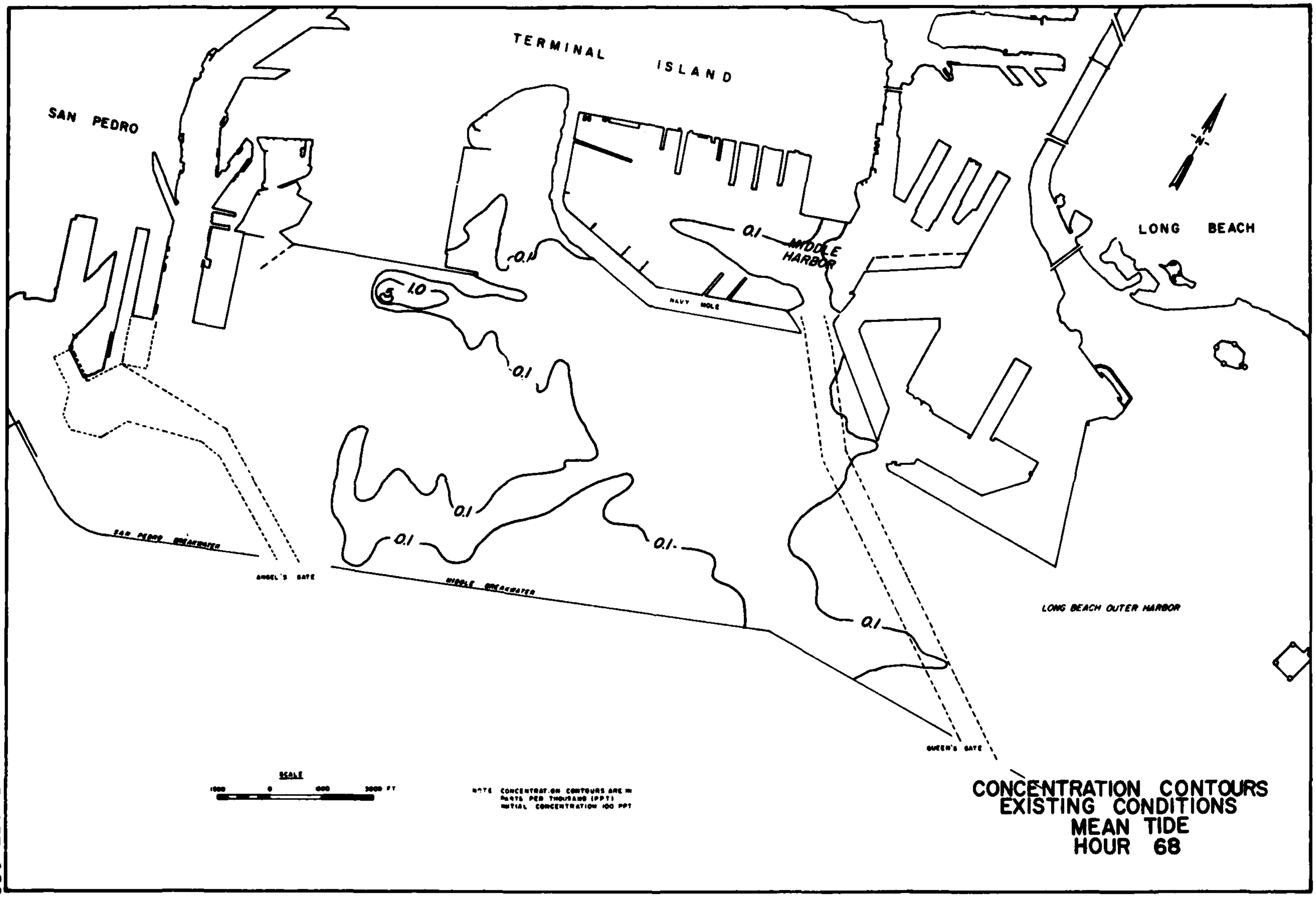

CONCENTRATION CONTOURS
EXISTING CONDITIONS
MEAN TIDE
HOUR 62
LONG BEACH
LONG BEACH OUTER HARBOR
TERMINAL ISLAND
MIDDLE HARBOR
NAVY MOLE
QUEEN'S GATE
ANGEL'S GATE
MIDDLE BREAKWATER
SAN PEDRO BREAKWATER
SAN PEDRO
0.1
0.1
0.1
0.1
0.1
0.1
0.1
10
SCALE

PLATE 102



CONCENTRATION CONTOURS
EXISTING CONDITIONS
MEAN TIDE
HOUR 68

PLATE 103

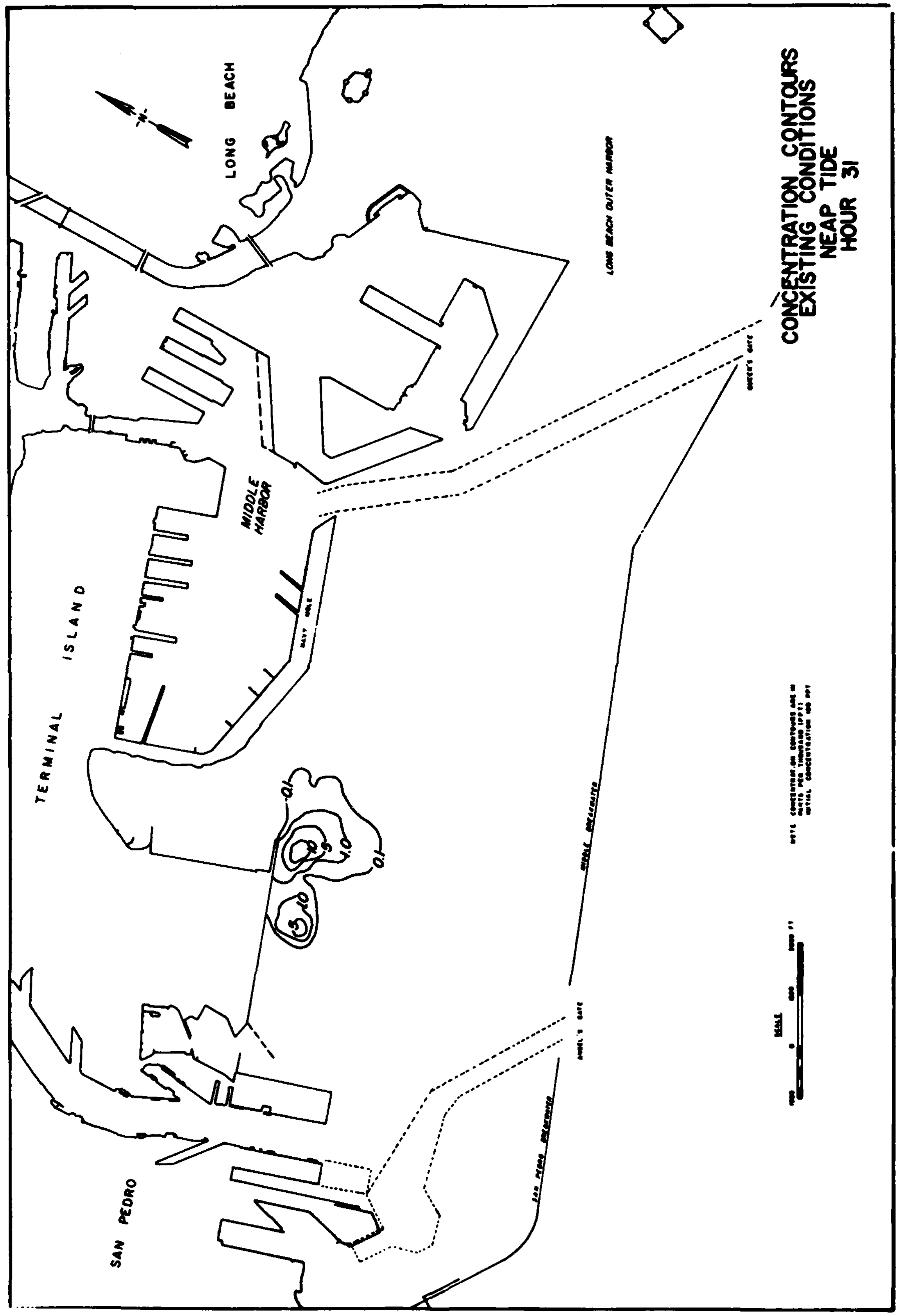

CONCENTRATION CONTOURS
EXISTING CONDITIONS
NEAP TIDE
HOUR 31
LONG BEACH
LONG BEACH OUTER HARBOR
MIDDLE HARBOR
TERMINAL ISLAND
SAN PEDRO
0.1
1.0
10
0.1

PLATE 104

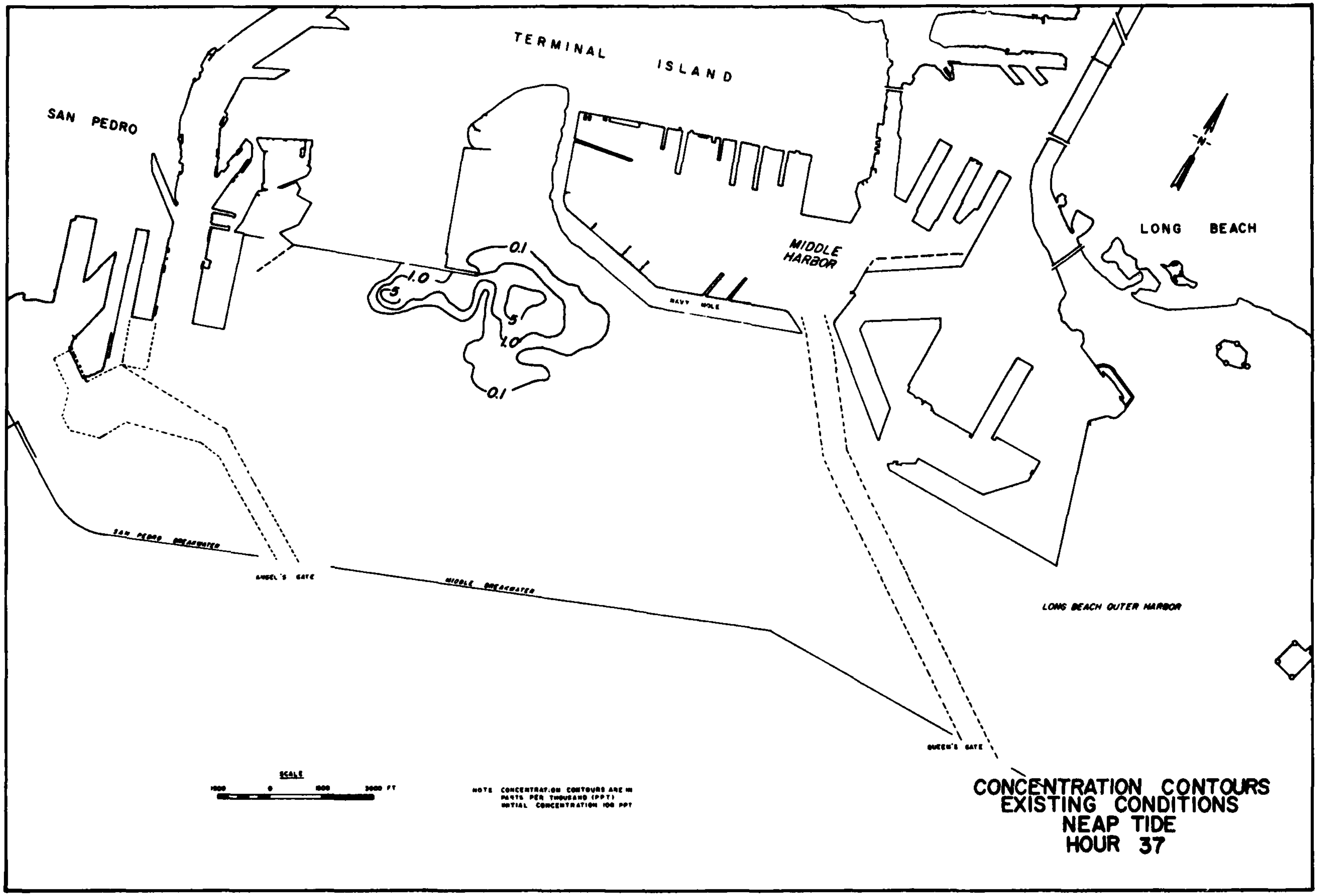

TERMINAL ISLAND
SAN PEDRO
LONG BEACH
MIDDLE HARBOR
NAVY MOLE
0.1
1.0
5
SAN PEDRO BREAKWATER
ANGEL'S GATE
MIDDLE BREAKWATER
LONG BEACH OUTER HARBOR
QUEEN'S GATE
SCALE
1000 0 1000 2000 FT
NOTE CONCENTRATION CONTOURS ARE IN PARTS PER THOUSAND (PPT)
INITIAL CONCENTRATION 100 PPT
CONCENTRATION CONTOURS
EXISTING CONDITIONS
NEAP TIDE
HOUR 37

PLATE 105

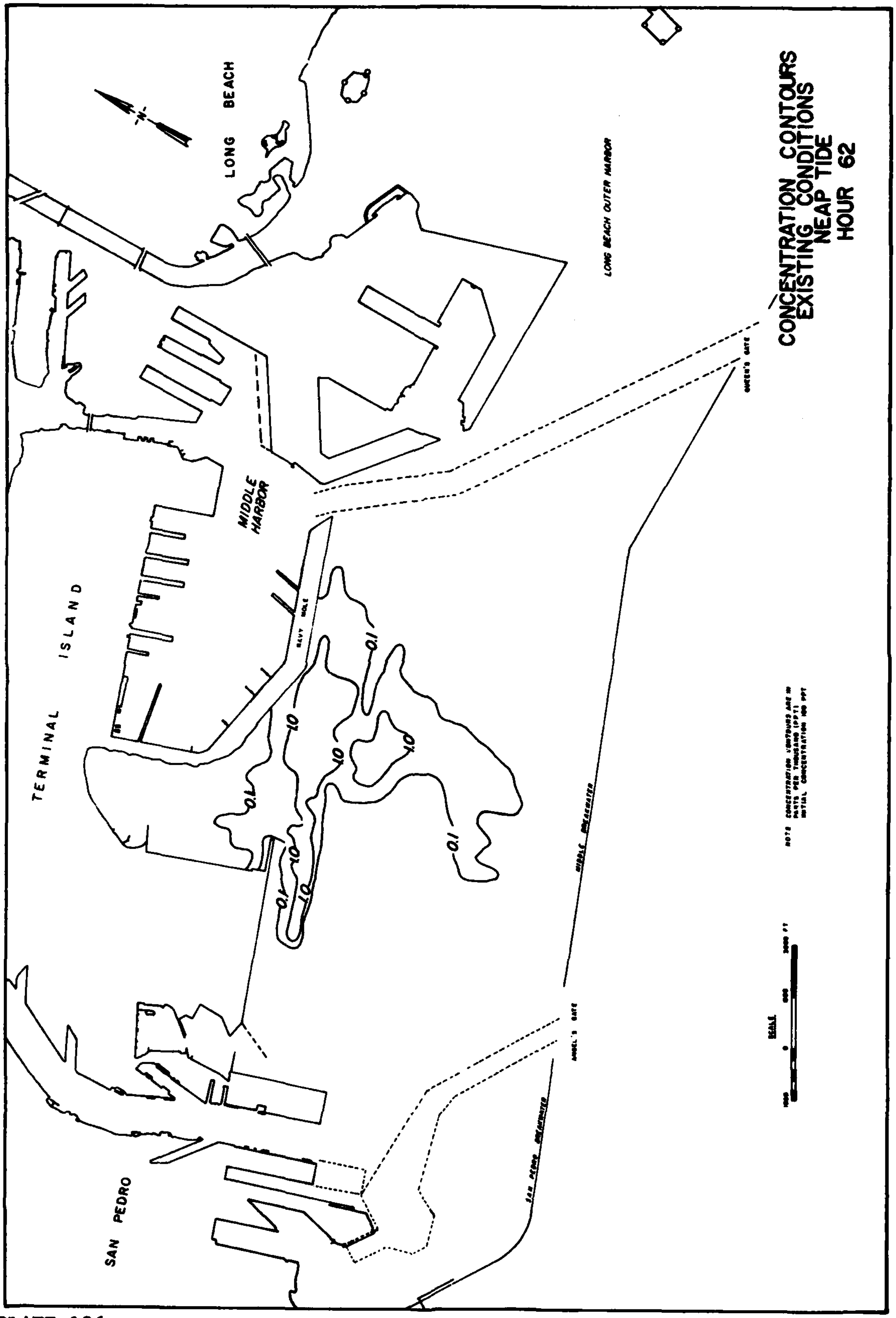

CONCENTRATION CONTOURS
EXISTING CONDITIONS
NEAP TIDE
HOUR 62
LONG BEACH
LONG BEACH OUTER HARBOR
MIDDLE HARBOR
TERMINAL ISLAND
NAVY MOLE
SAN PEDRO
MIDDLE BREAKWATER
SAN PEDRO BREAKWATER
QUEEN'S GATE
ANGEL'S GATE
0.1
1.0
SCALE

PLATE 106

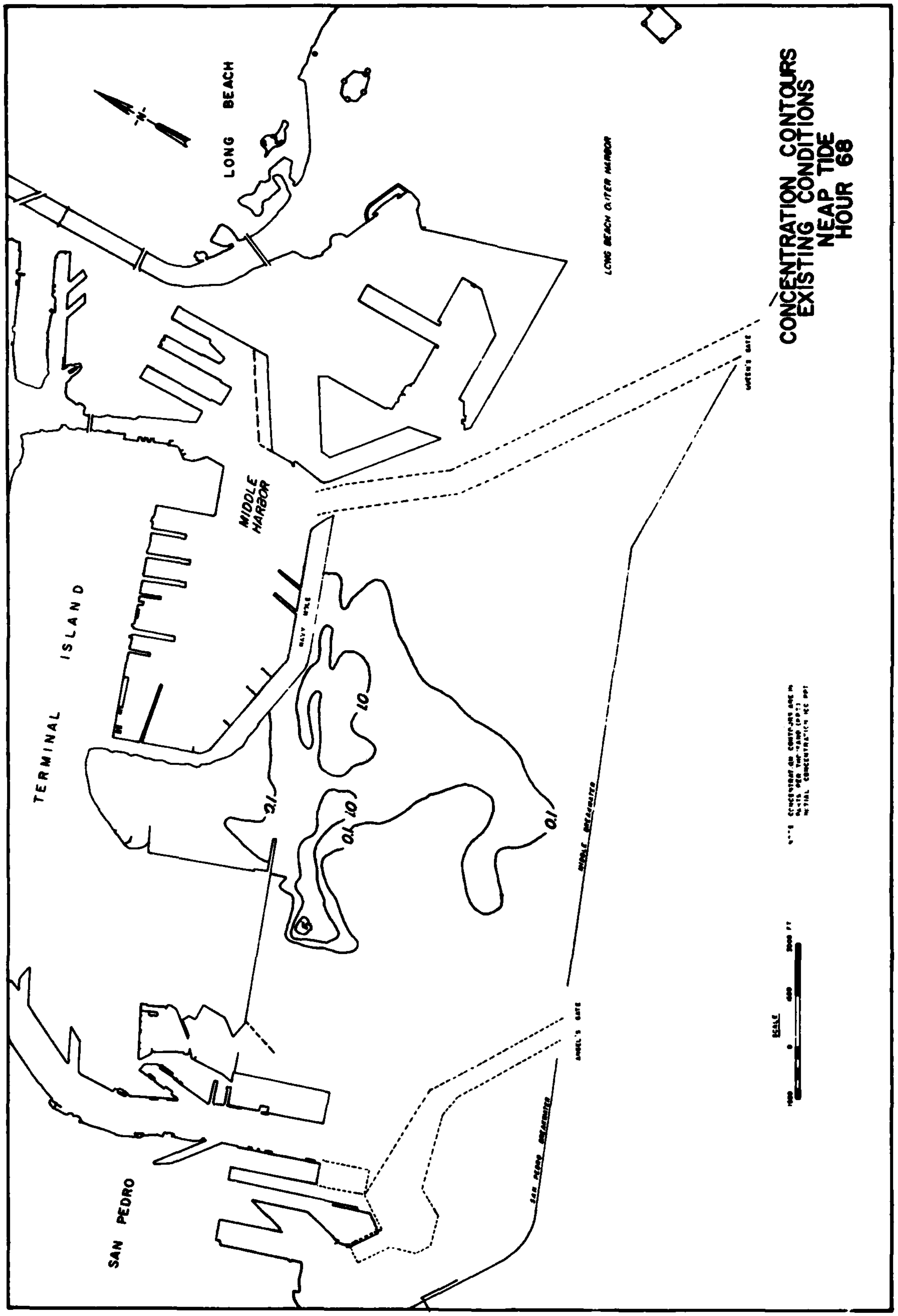

CONCENTRATION CONTOURS
EXISTING CONDITIONS
NEAP TIDE
HOUR 68
LONG BEACH
LONG BEACH OUTER HARBOR
QUEEN'S GATE
MIDDLE HARBOR
TERMINAL ISLAND
NAVY MOLE
1.0
0.1
MIDDLE BREAKWATER
ANGEL'S GATE
SAN PEDRO BREAKWATER
SAN PEDRO
SCALE

PLATE 107

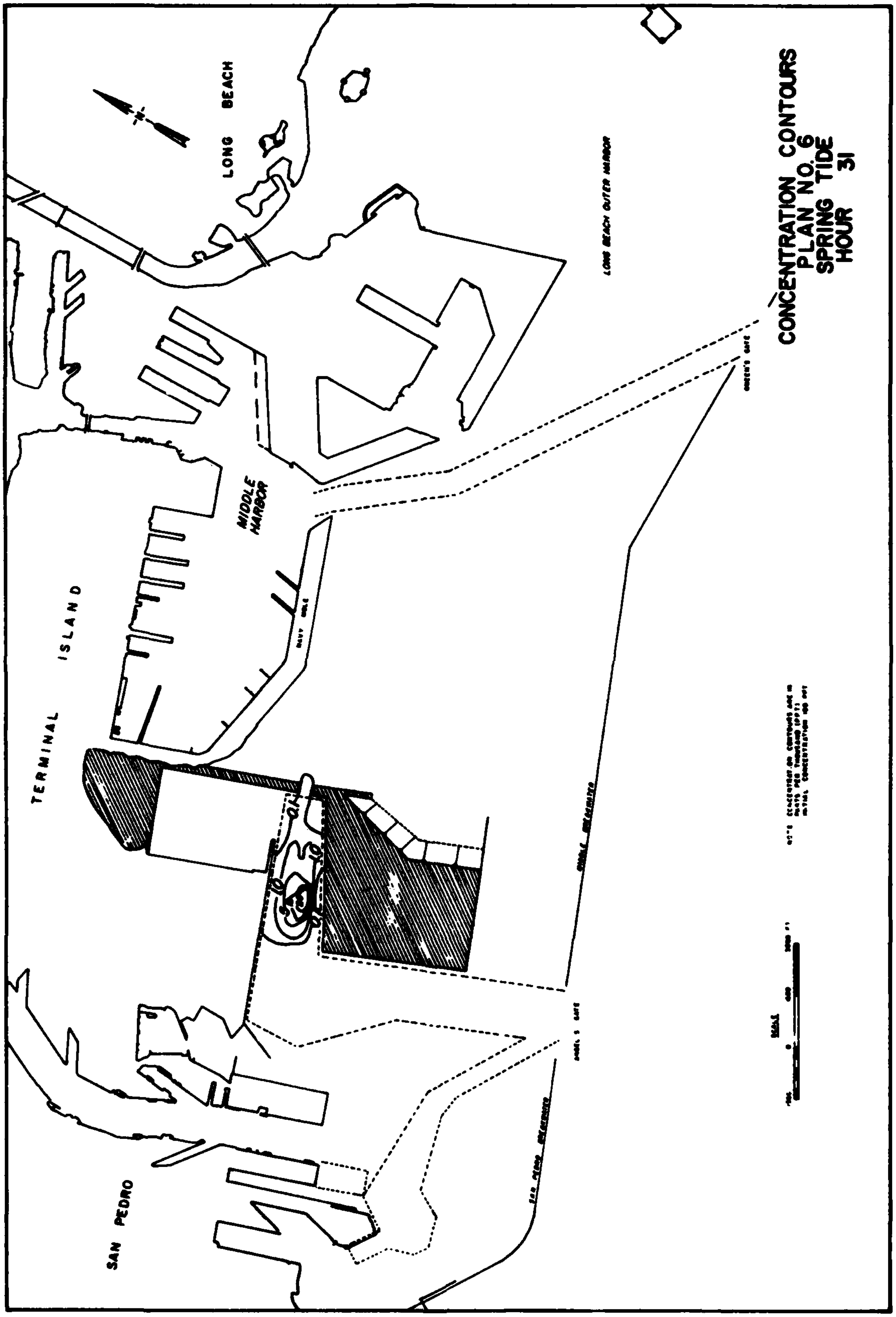

CONCENTRATION CONTOURS
PLAN NO. 6
SPRING TIDE
HOUR 31
LONG BEACH
TERMINAL ISLAND
MIDDLE HARBOR
SAN PEDRO
LONG BEACH OUTER HARBOR

PLATE 108

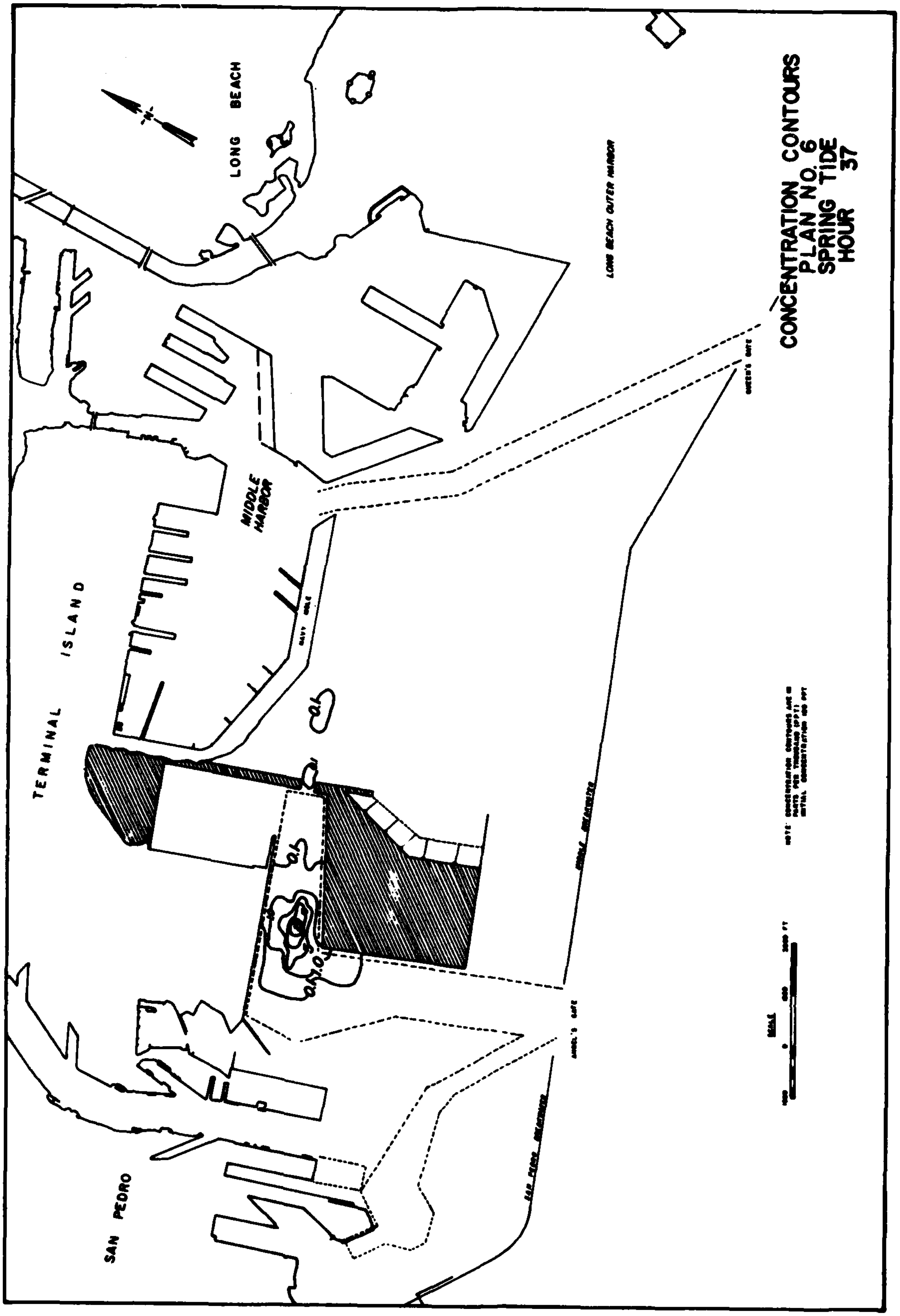

CONCENTRATION CONTOURS
PLAN NO. 6
SPRING TIDE
HOUR 37
LONG BEACH
LONG BEACH OUTER HARBOR
MIDDLE HARBOR
TERMINAL ISLAND
NAVY MOLE
SAN PEDRO
QUEEN'S GATE
ANGEL'S GATE
MIDDLE BREAKWATER
SAN PEDRO BREAKWATER
0.1
0.1
0.1

PLATE 109

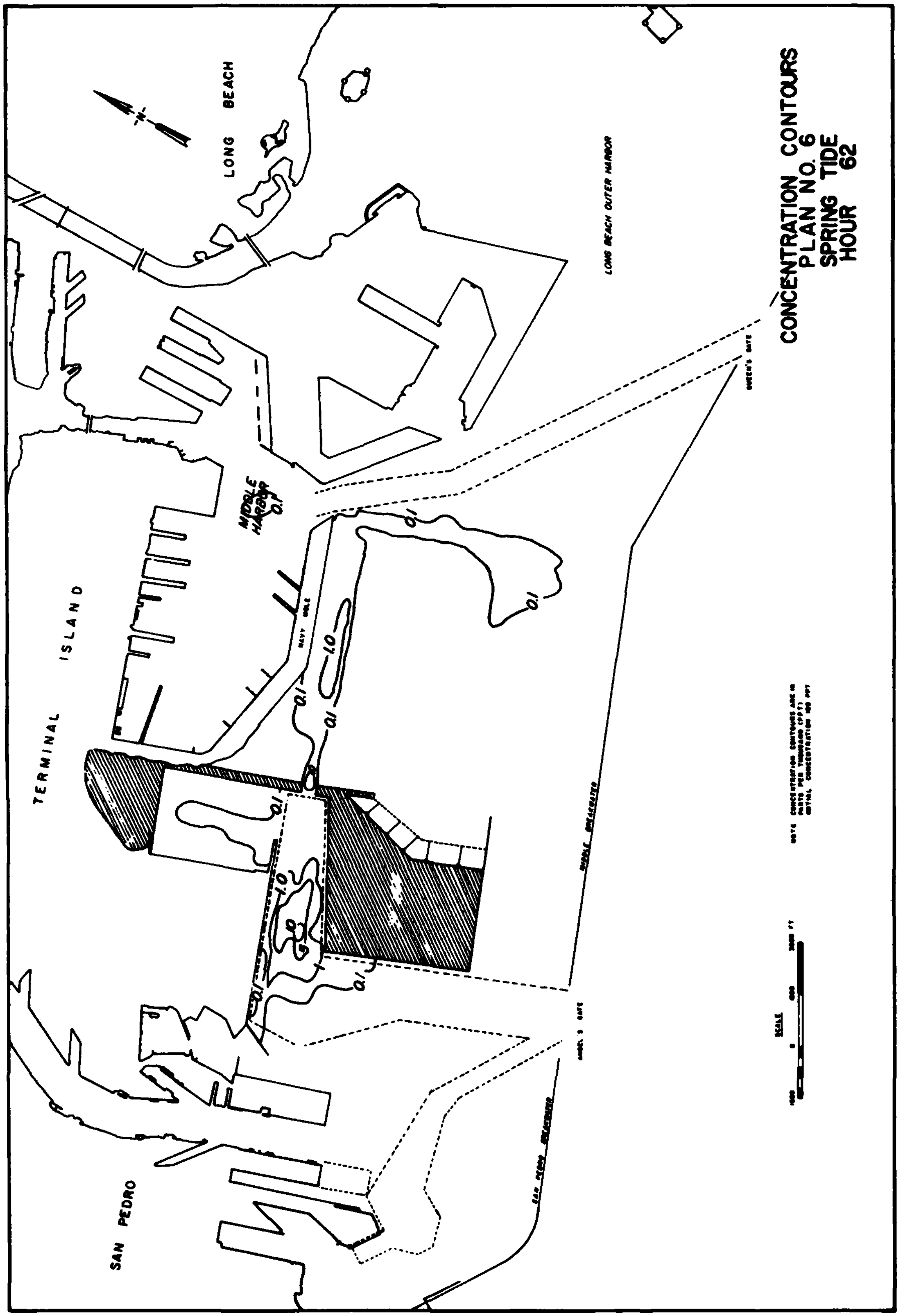

CONCENTRATION CONTOURS
PLAN NO. 6
SPRING TIDE
HOUR 62
LONG BEACH
LONG BEACH OUTER HARBOR
TERMINAL ISLAND
MIDDLE HARBOR
SAN PEDRO
0.1
1.0

PLATE 110

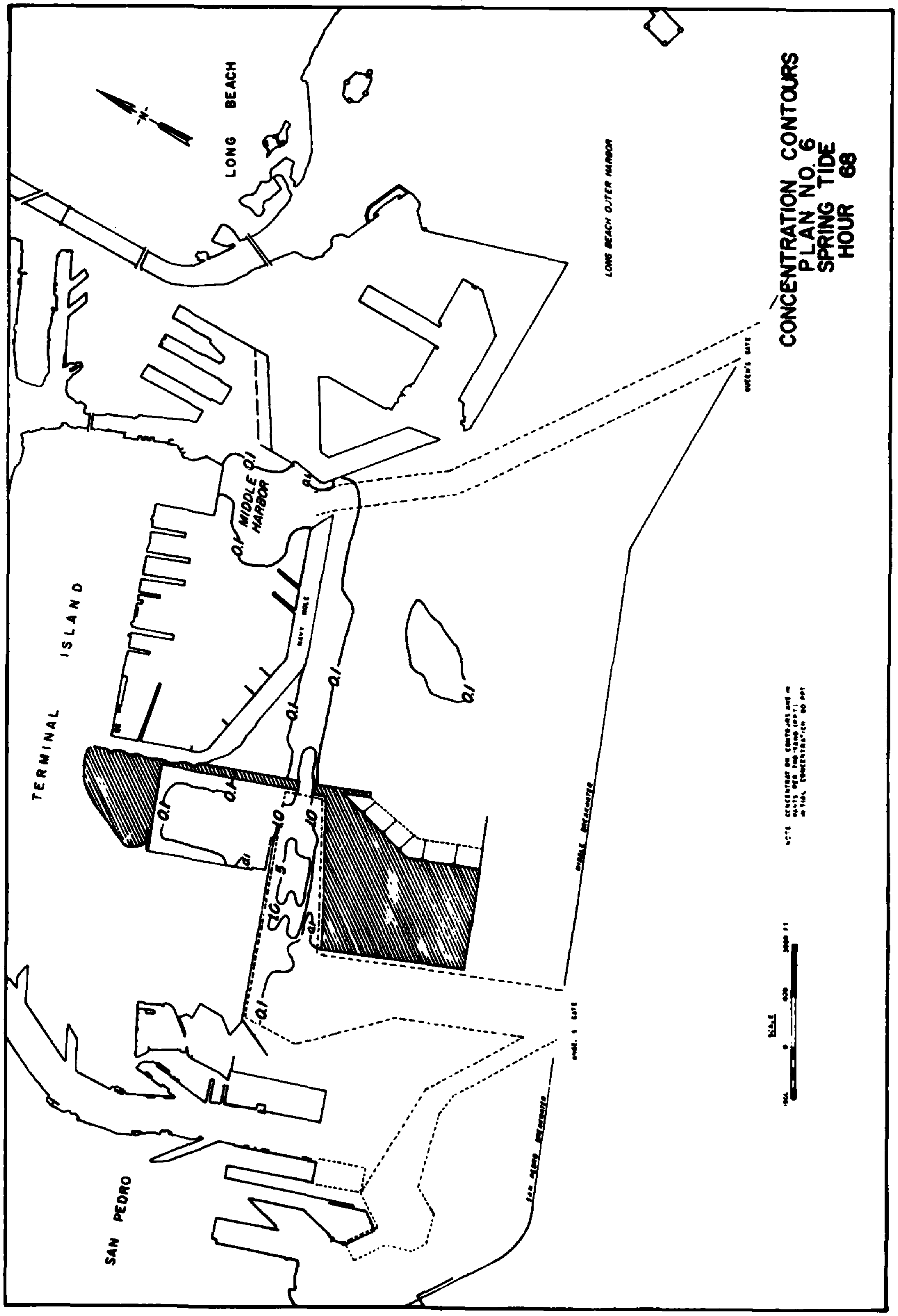

CONCENTRATION CONTOURS
PLAN NO. 6
SPRING TIDE
HOUR 68
LONG BEACH
LONG BEACH OUTER HARBOR
MIDDLE HARBOR
TERMINAL ISLAND
SAN PEDRO
QUEEN'S GATE
NAVY MOLE
0.1
1.0
5
SCALE

PLATE 111

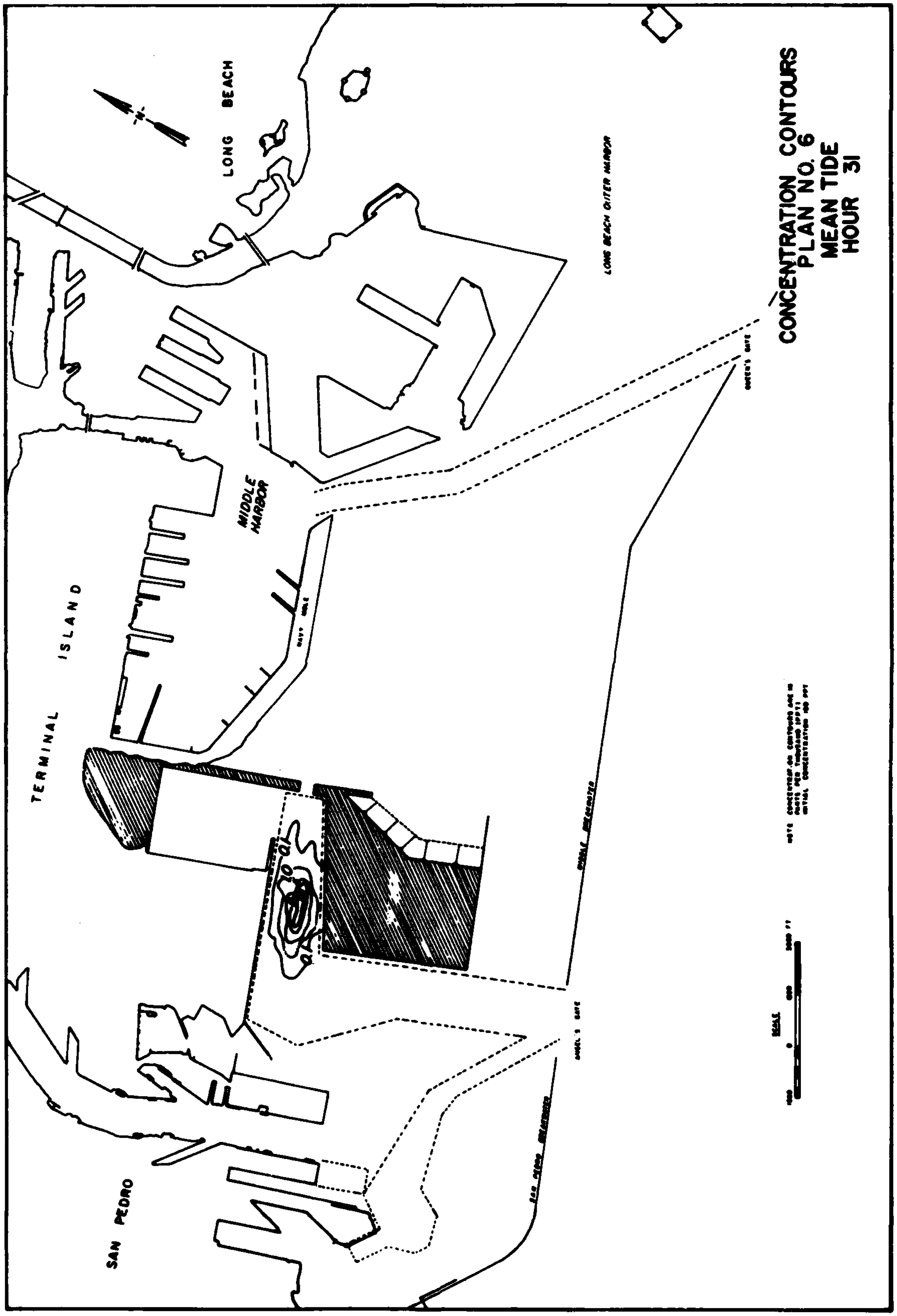
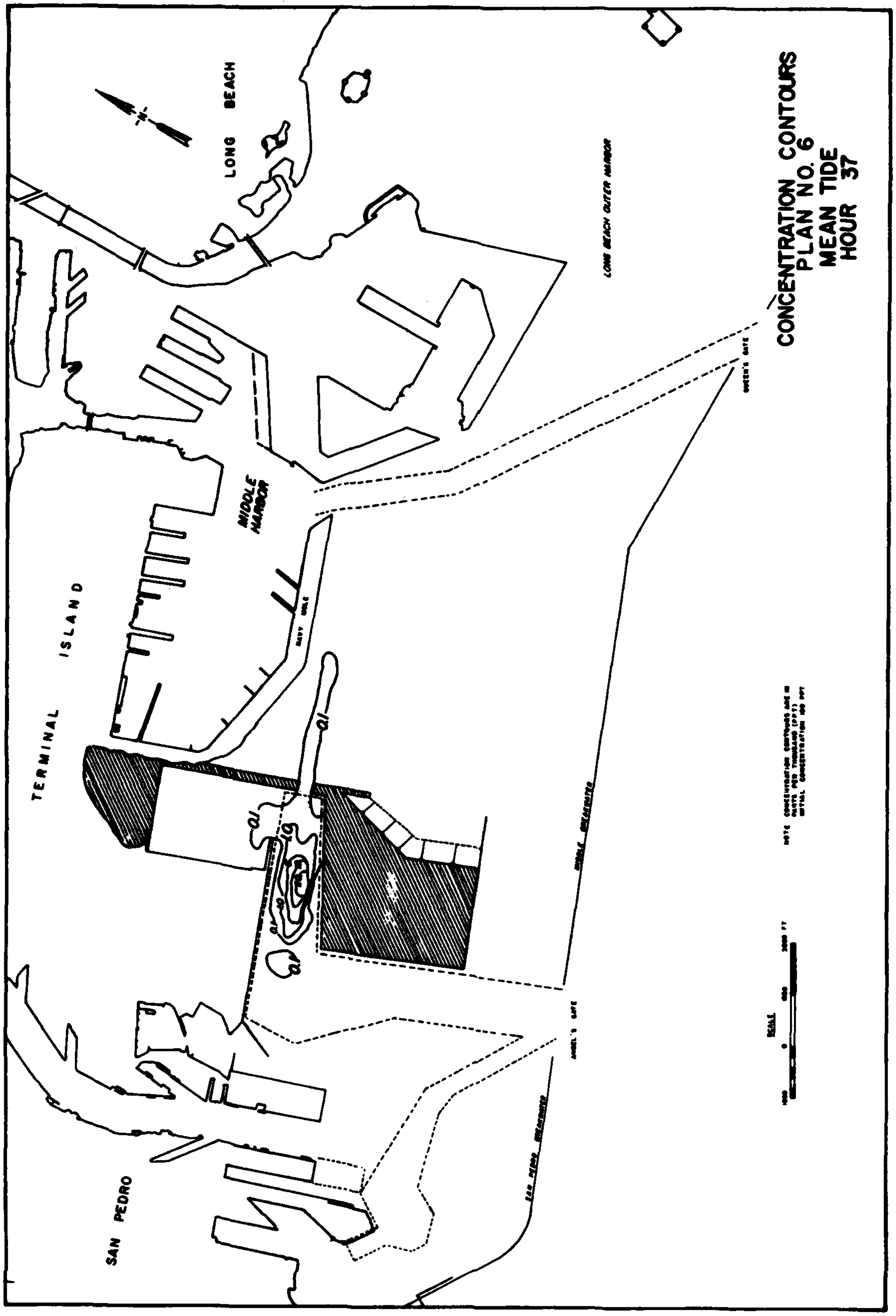

CONCENTRATION CONTOURS
PLAN NO. 6
MEAN TIDE
HOUR 31
LONG BEACH
LONG BEACH OUTER HARBOR
MIDDLE HARBOR
TERMINAL ISLAND
SAN PEDRO

PLATE 112



CONCENTRATION CONTOURS
PLAN NO. 6
MEAN TIDE
HOUR 37
LONG BEACH
LONG BEACH OUTER HARBOR
MIDDLE HARBOR
TERMINAL ISLAND
NAVY MOLE
SAN PEDRO
QUEEN'S GATE
ANGEL'S GATE
MIDDLE BREAKWATER
SAN PEDRO BREAKWATER
SCALE
1000 0 1000 2000 FT
0.1
1.0

PLATE 113

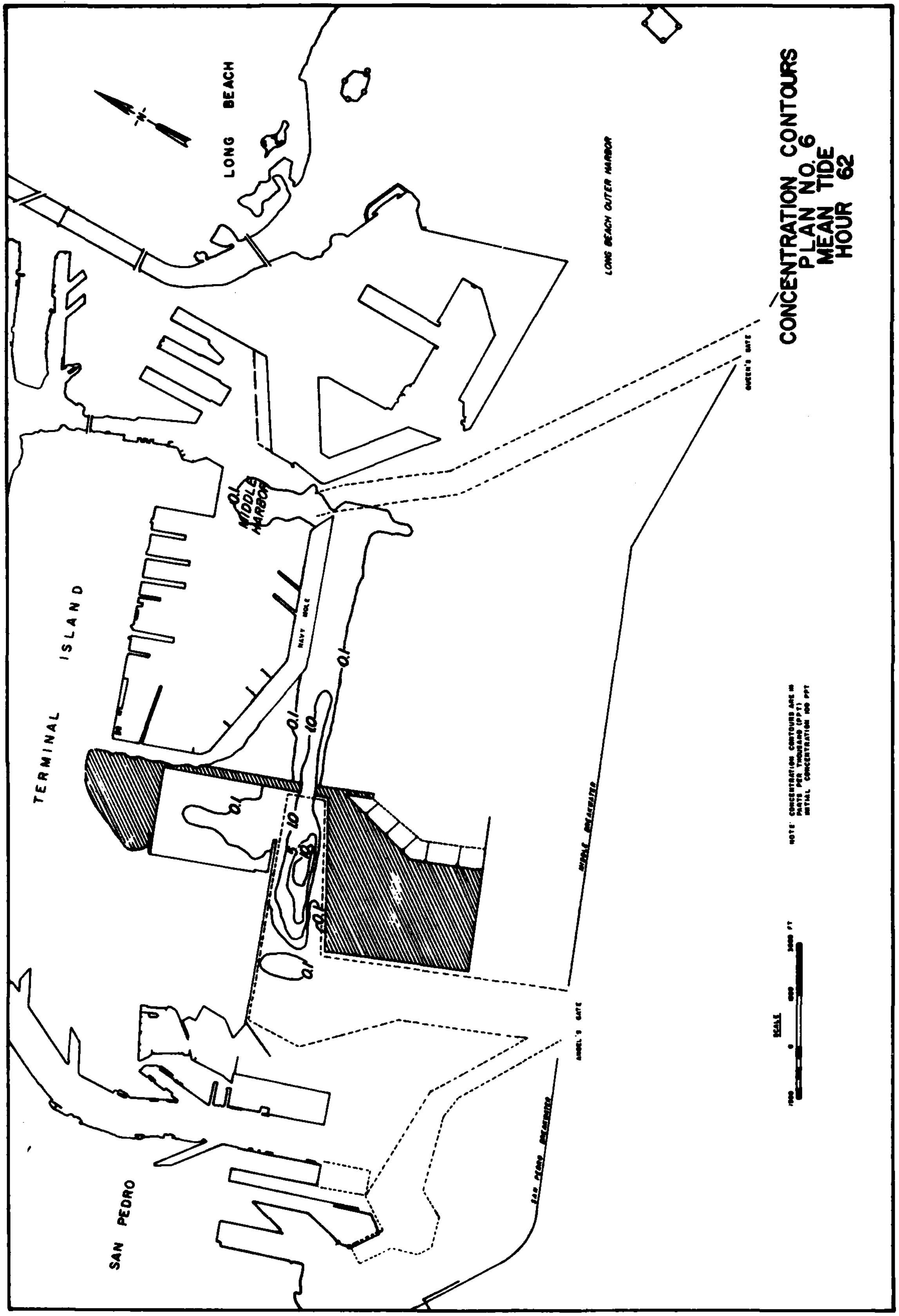

CONCENTRATION CONTOURS
PLAN NO. 6
MEAN TIDE
HOUR 62
LONG BEACH
LONG BEACH OUTER HARBOR
TERMINAL ISLAND
SAN PEDRO
MIDDLE HARBOR
NAVY MOLE
0.1
1.0

PLATE 114

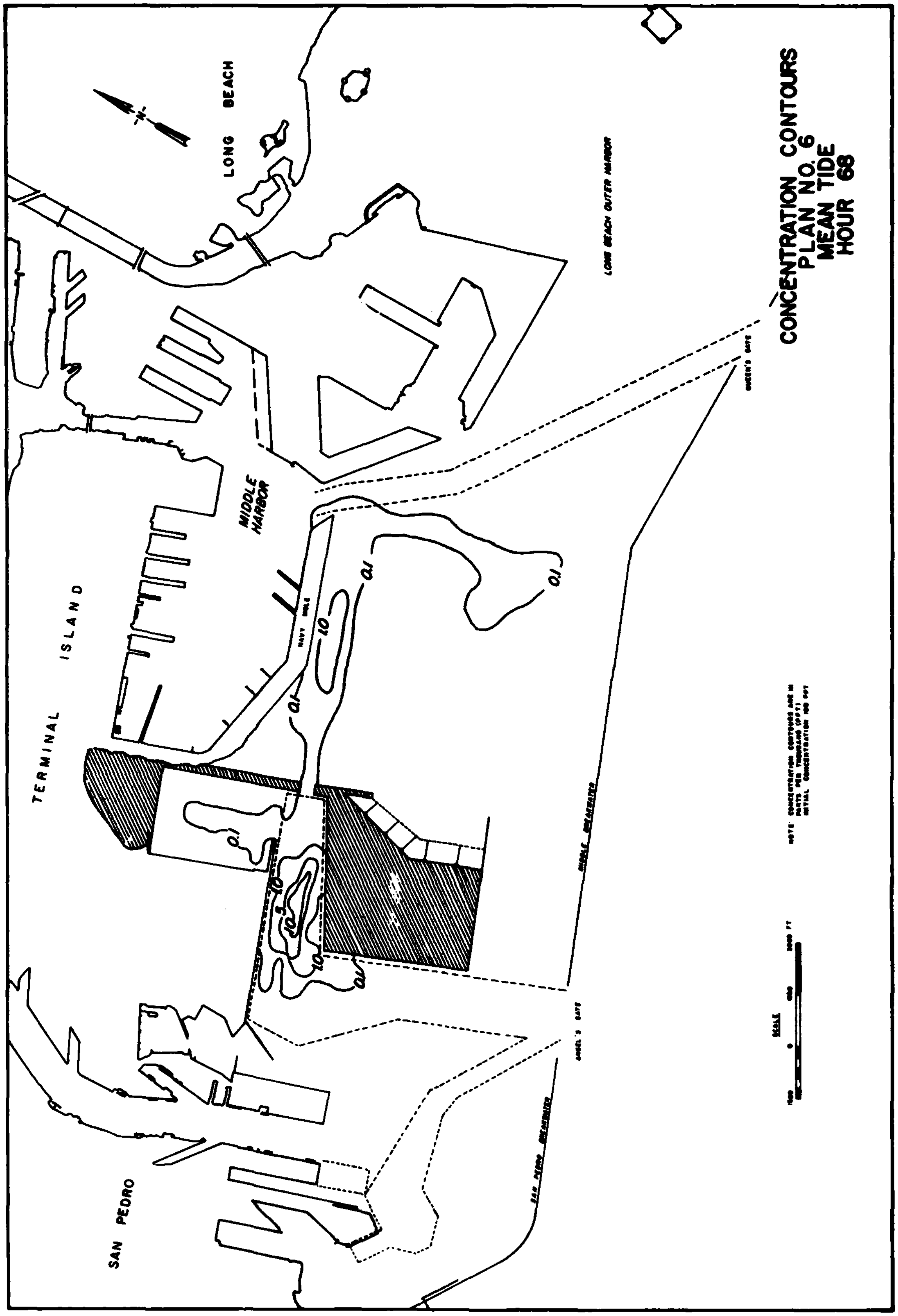

CONCENTRATION CONTOURS
PLAN NO. 6
MEAN TIDE
HOUR 68
LONG BEACH
LONG BEACH OUTER HARBOR
MIDDLE HARBOR
TERMINAL ISLAND
NAVY MOLE
MIDDLE BREAKWATER
SAN PEDRO
SAN PEDRO BREAKWATER

PLATE 115

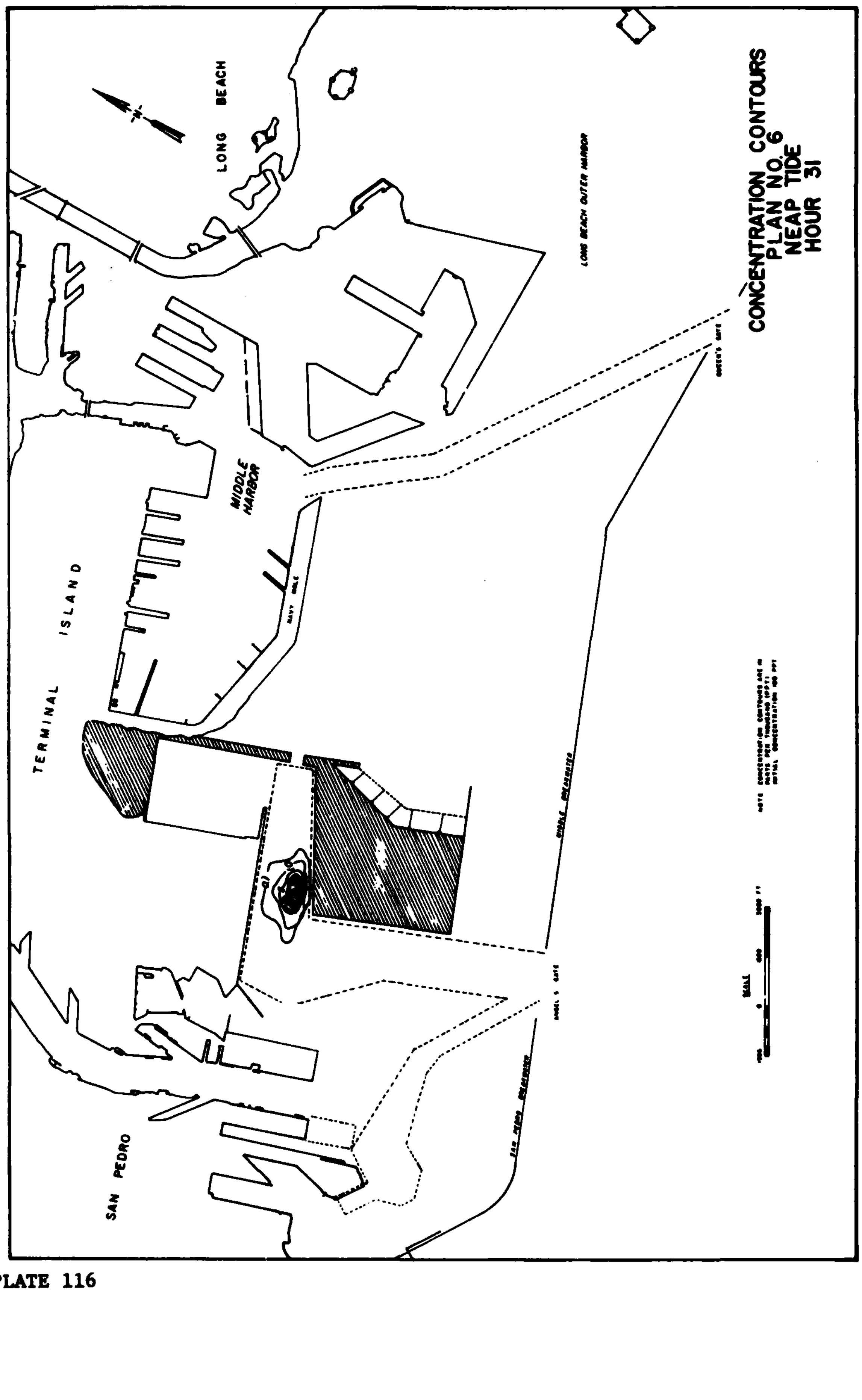

CONCENTRATION CONTOURS
PLAN NO. 6
NEAP TIDE
HOUR 31
LONG BEACH
LONG BEACH OUTER HARBOR
MIDDLE HARBOR
TERMINAL ISLAND
SAN PEDRO

PLATE 116

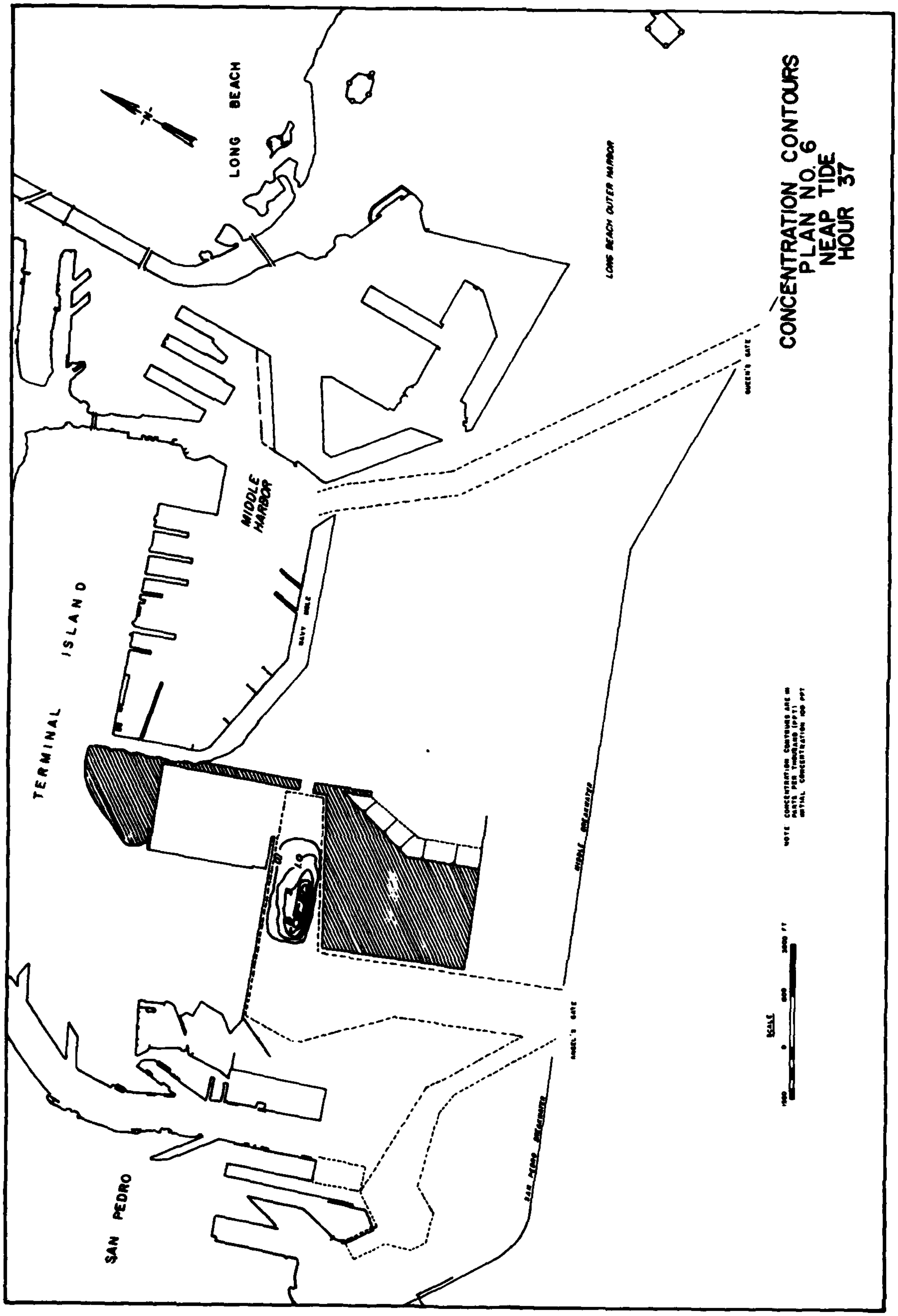

LONG BEACH
TERMINAL ISLAND
MIDDLE HARBOR
SAN PEDRO
LONG BEACH OUTER HARBOR
QUEEN'S GATE
ANGEL'S GATE
NAVY MOLE
MIDDLE BREAKWATER
SAN PEDRO BREAKWATER
NOTE: CONCENTRATION CONTOURS ARE IN PARTS PER THOUSAND (PPT) INITIAL CONCENTRATION 100 PPT
SCALE
0
3000 FT
CONCENTRATION CONTOURS
PLAN NO. 6
NEAP TIDE
HOUR 37

PLATE 117

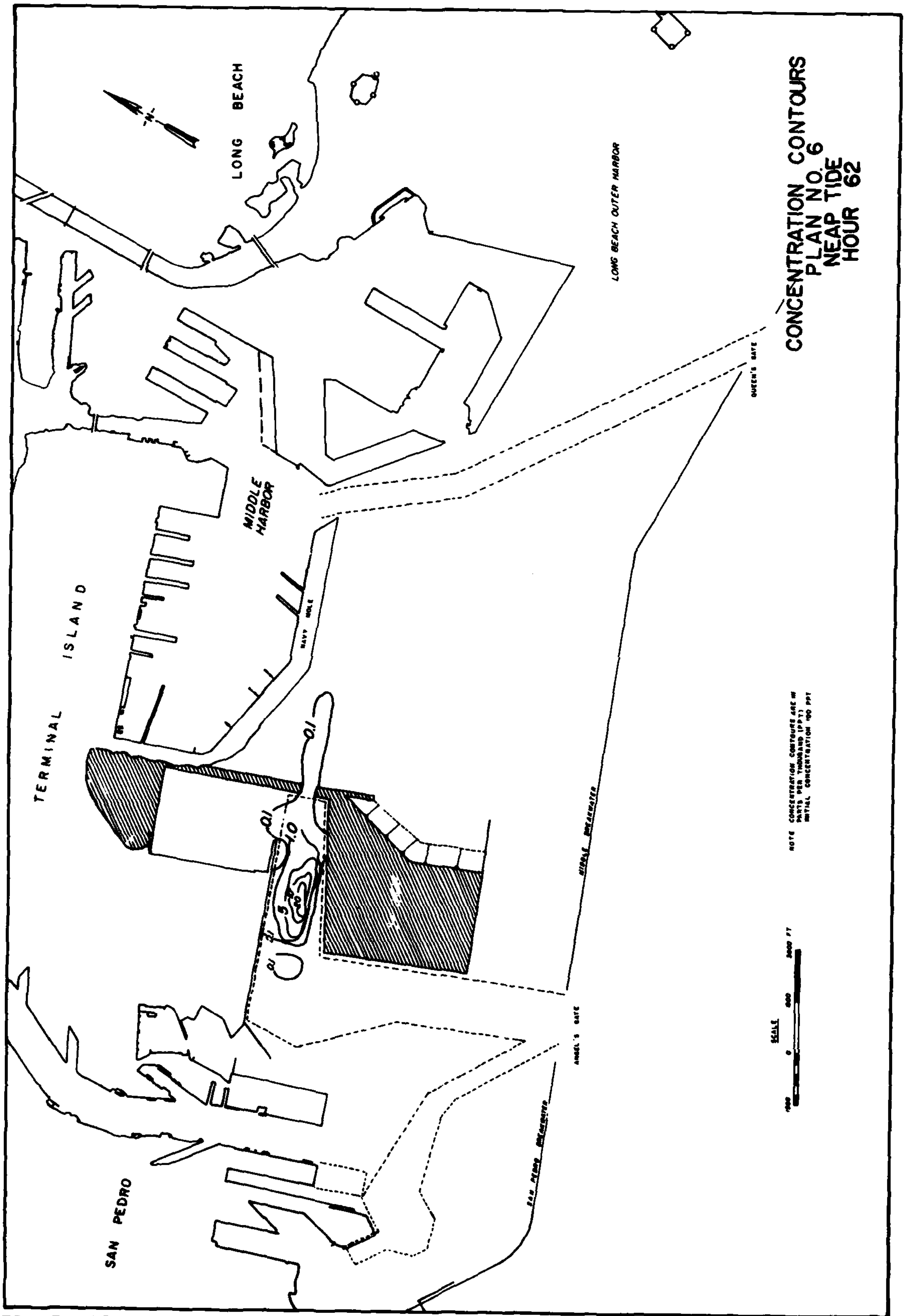

CONCENTRATION CONTOURS
PLAN NO. 6
NEAP TIDE
HOUR 62
LONG BEACH
LONG BEACH OUTER HARBOR
QUEEN'S GATE
MIDDLE HARBOR
TERMINAL ISLAND
NAVY MOLE
MIDDLE BREAKWATER
ANGEL'S GATE
SAN PEDRO BREAKWATER
SAN PEDRO
0.1
1.0
SCALE

PLATE 118

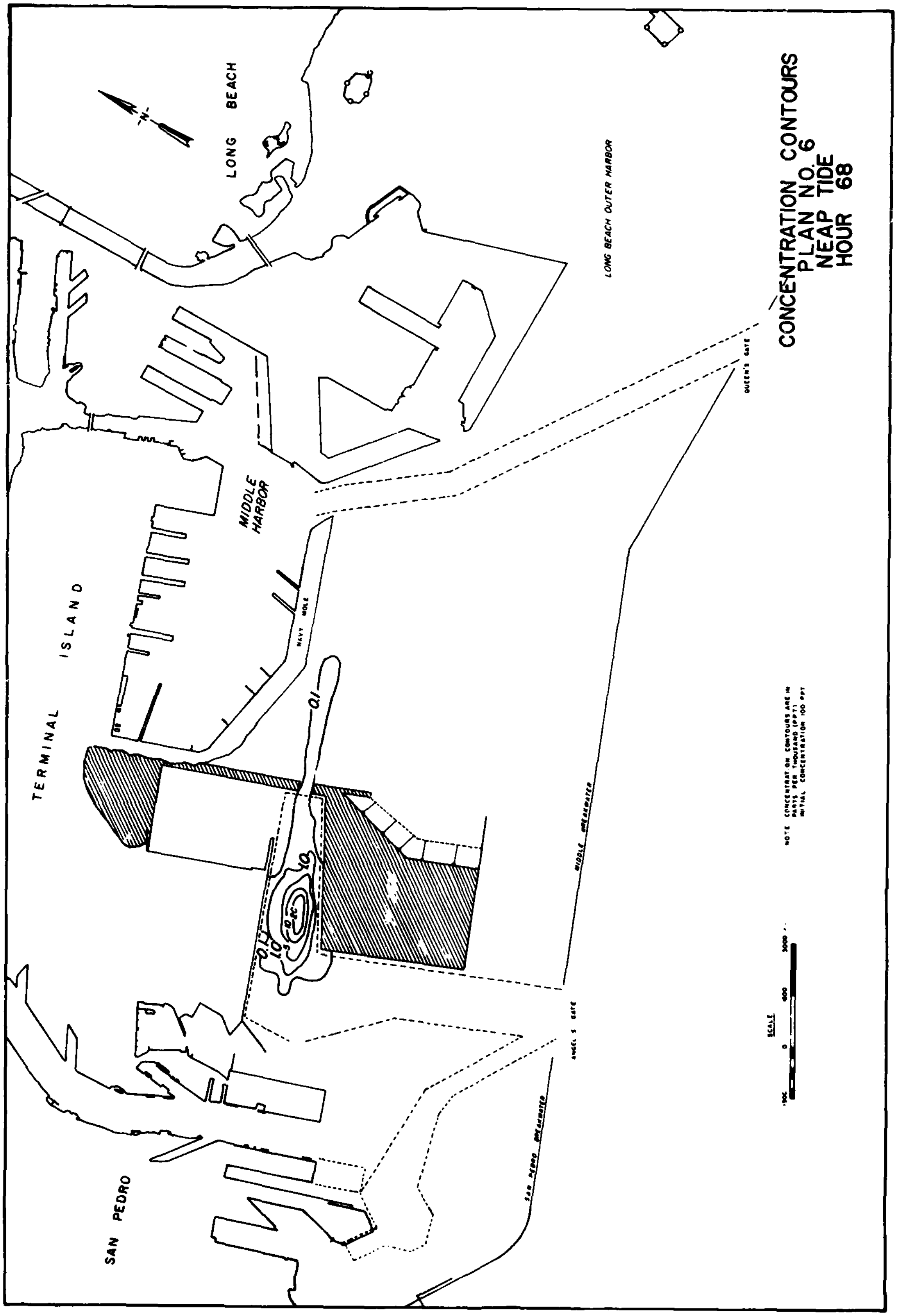

CONCENTRATION CONTOURS
PLAN NO. 6
NEAP TIDE
HOUR 68
LONG BEACH
LONG BEACH OUTER HARBOR
QUEEN'S GATE
MIDDLE HARBOR
TERMINAL ISLAND
NAVY MOLE
0.1
1.0
MIDDLE BREAKWATER
ANGEL'S GATE
SAN PEDRO BREAKWATER
SAN PEDRO
SCALE

PLATE 119

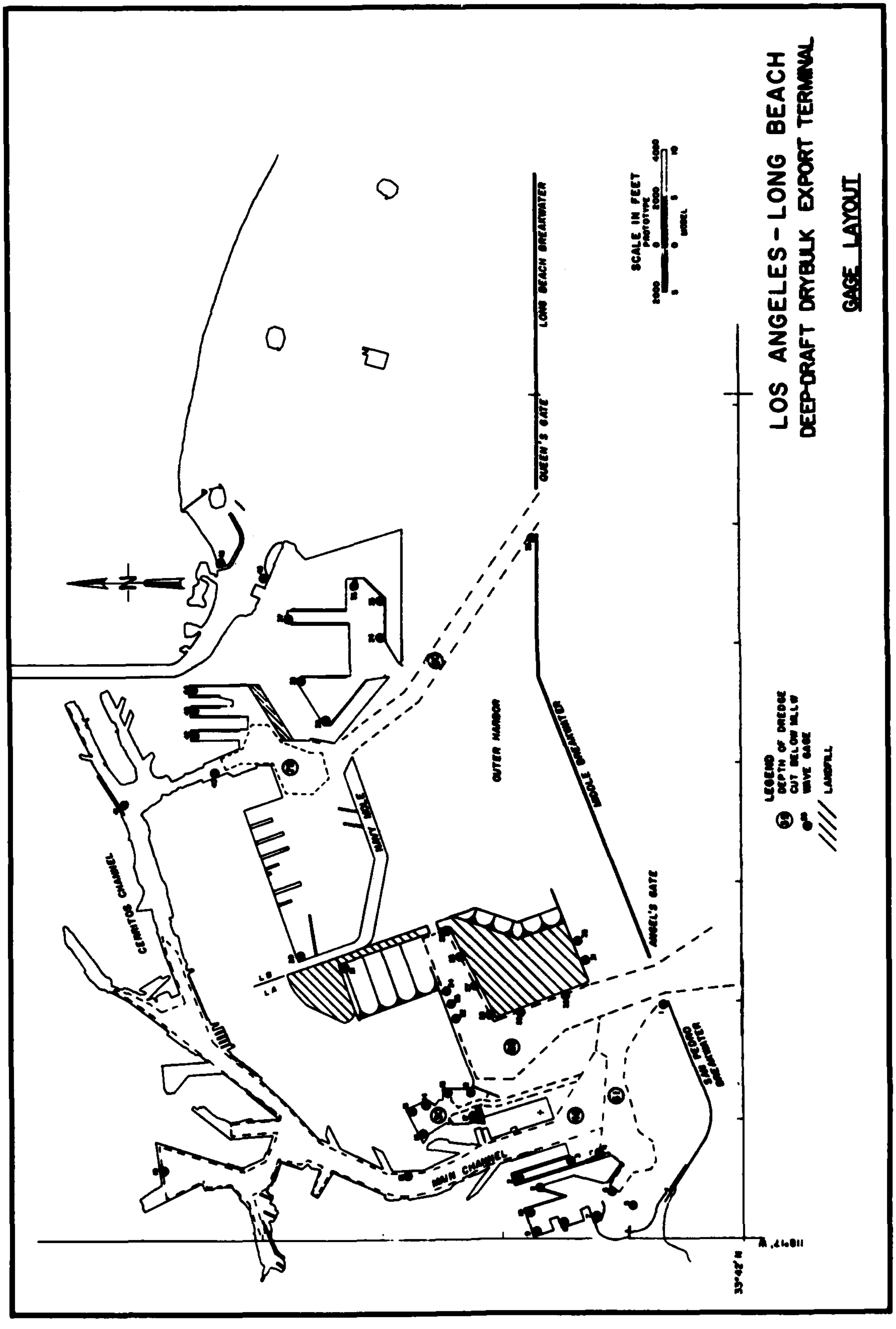
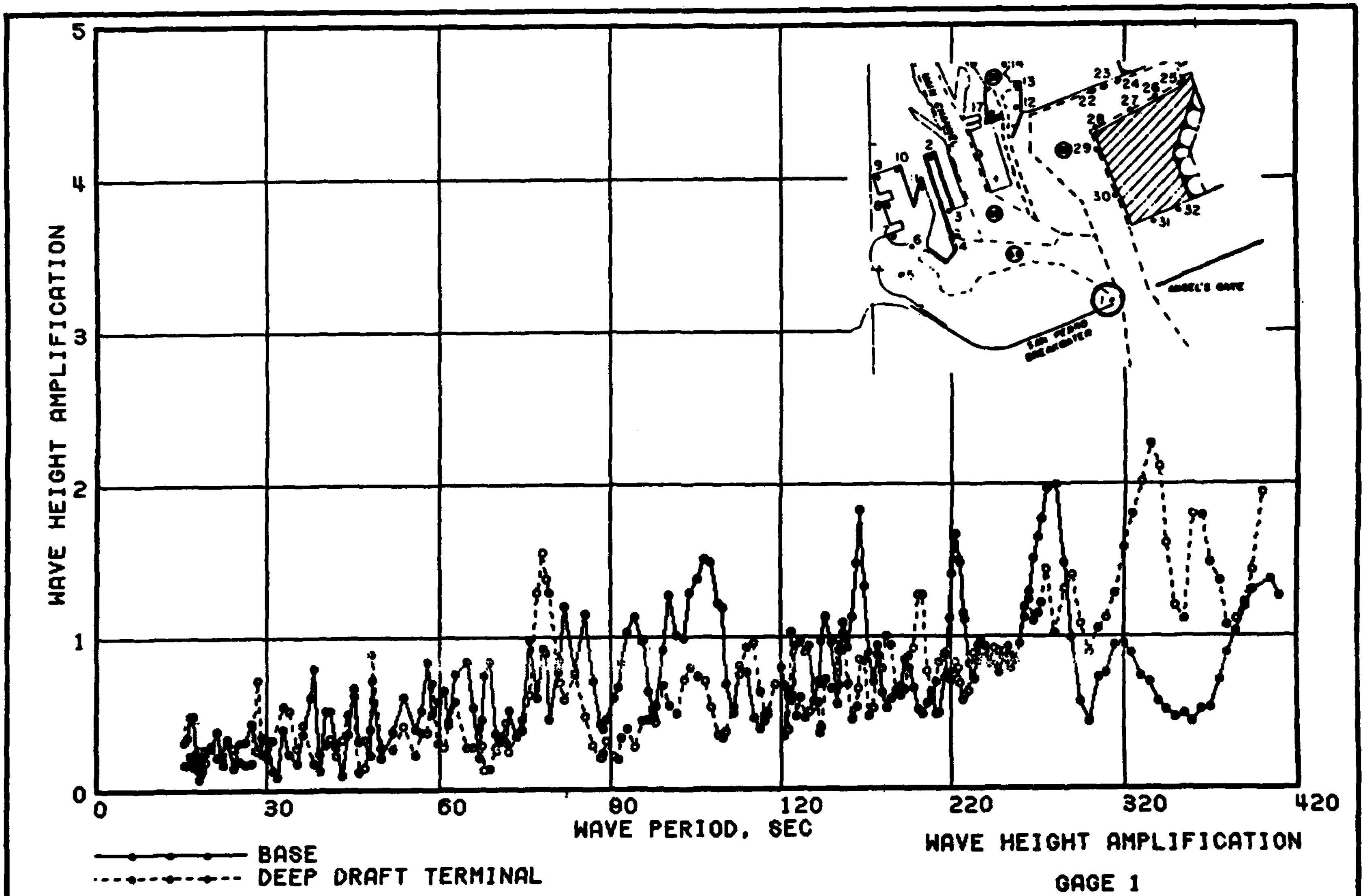
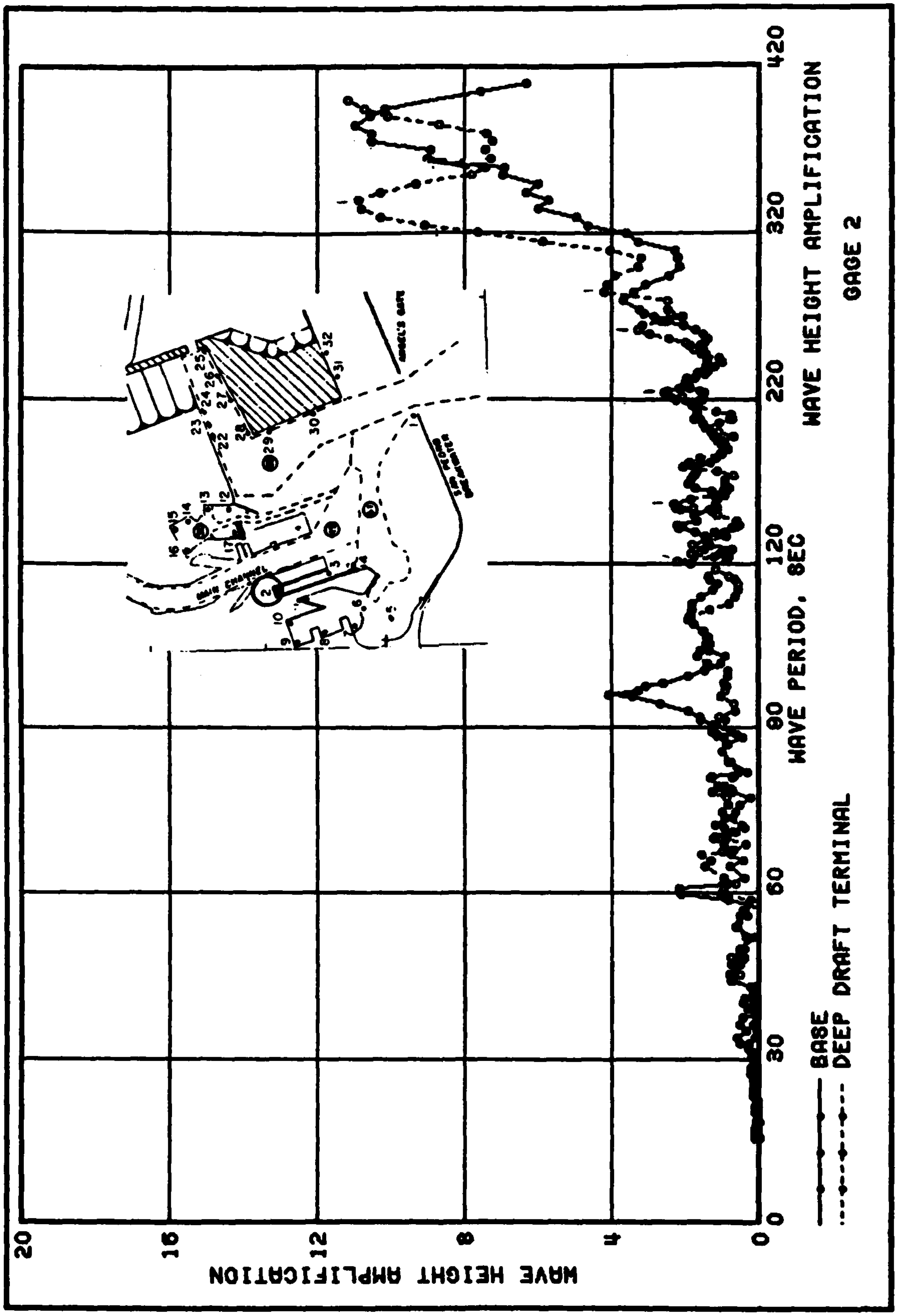

LOS ANGELES - LONG BEACH
DEEP-DRAFT DRYBULK EXPORT TERMINAL
GAGE LAYOUT
SCALE IN FEET
LONG BEACH BREAKWATER
QUEEN'S GATE
MIDDLE BREAKWATER
ANGEL'S GATE
SAN PEDRO BREAKWATER
OUTER HARBOR
NAVY MOLE
CERRITOS CHANNEL
MAIN CHANNEL
LEGEND
DEPTH OF DREDGE CUT BELOW MLLW
WAVE GAGE
LANDFILL

PLATE 120



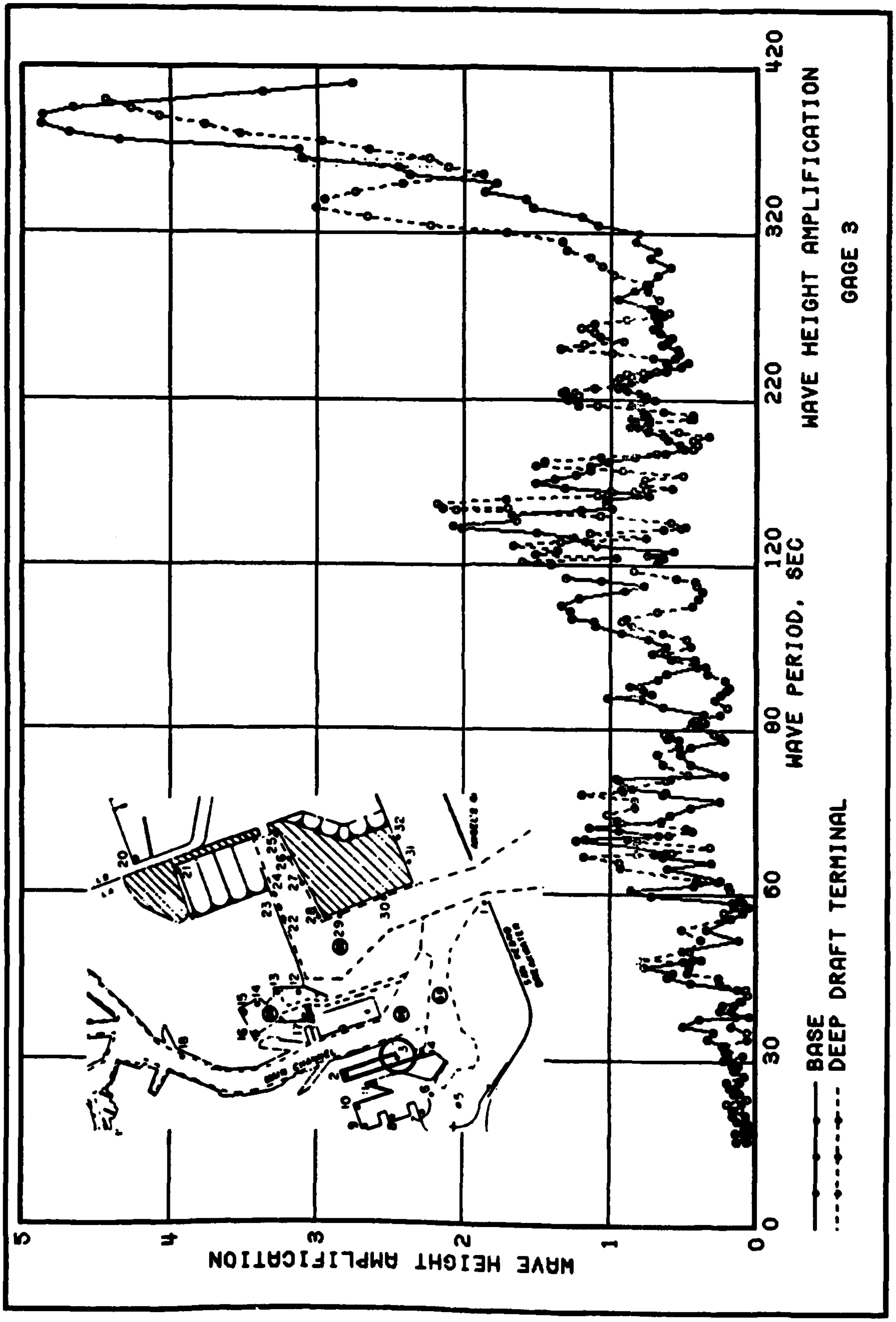
WAVE HEIGHT AMPLIFICATION

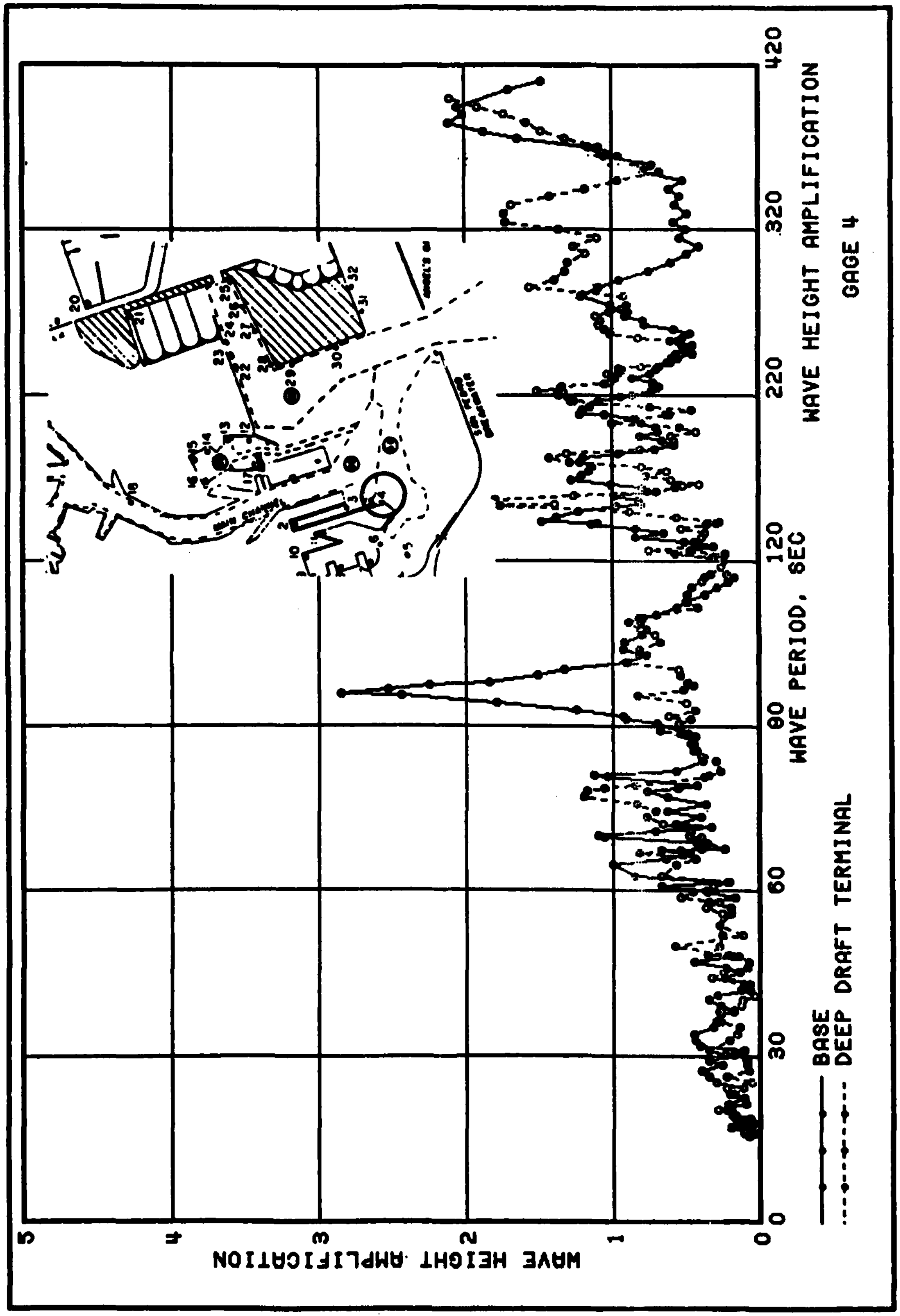
GAGE 1

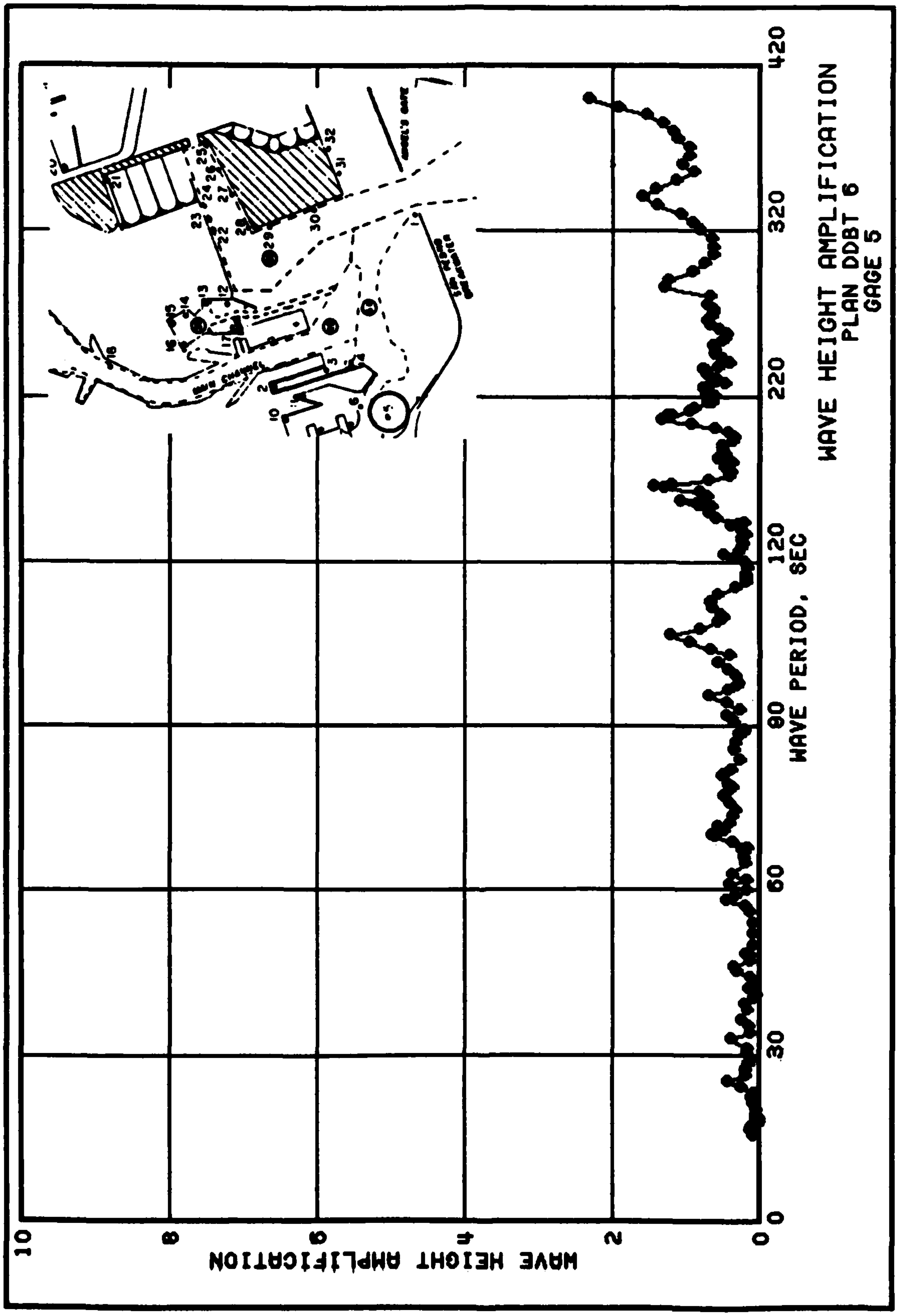


WAVE HEIGHT AMPLIFICATION
GAGE 2
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
BASE
DEEP DRAFT TERMINAL
0
30
60
90
120
220
320
420
0
4
8
12
16
20

PLATE 122


WAVE HEIGHT AMPLIFICATION
GAGE 3
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
BASE
DEEP DRAFT TERMINAL
0
30
60
80
120
220
320
420
0
1
2
3
4
5


WAVE HEIGHT AMPLIFICATION
GAGE 4
WAVE HEIGHT AMPLIFICATION
WAVE PERIOD, SEC
0
30
60
90
120
220
320
420
0
1
2
3
4
5
BASE
DEEP DRAFT TERMINAL



WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 5
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
0
30
60
90
120
220
320
420
0
2
4
6
8
10

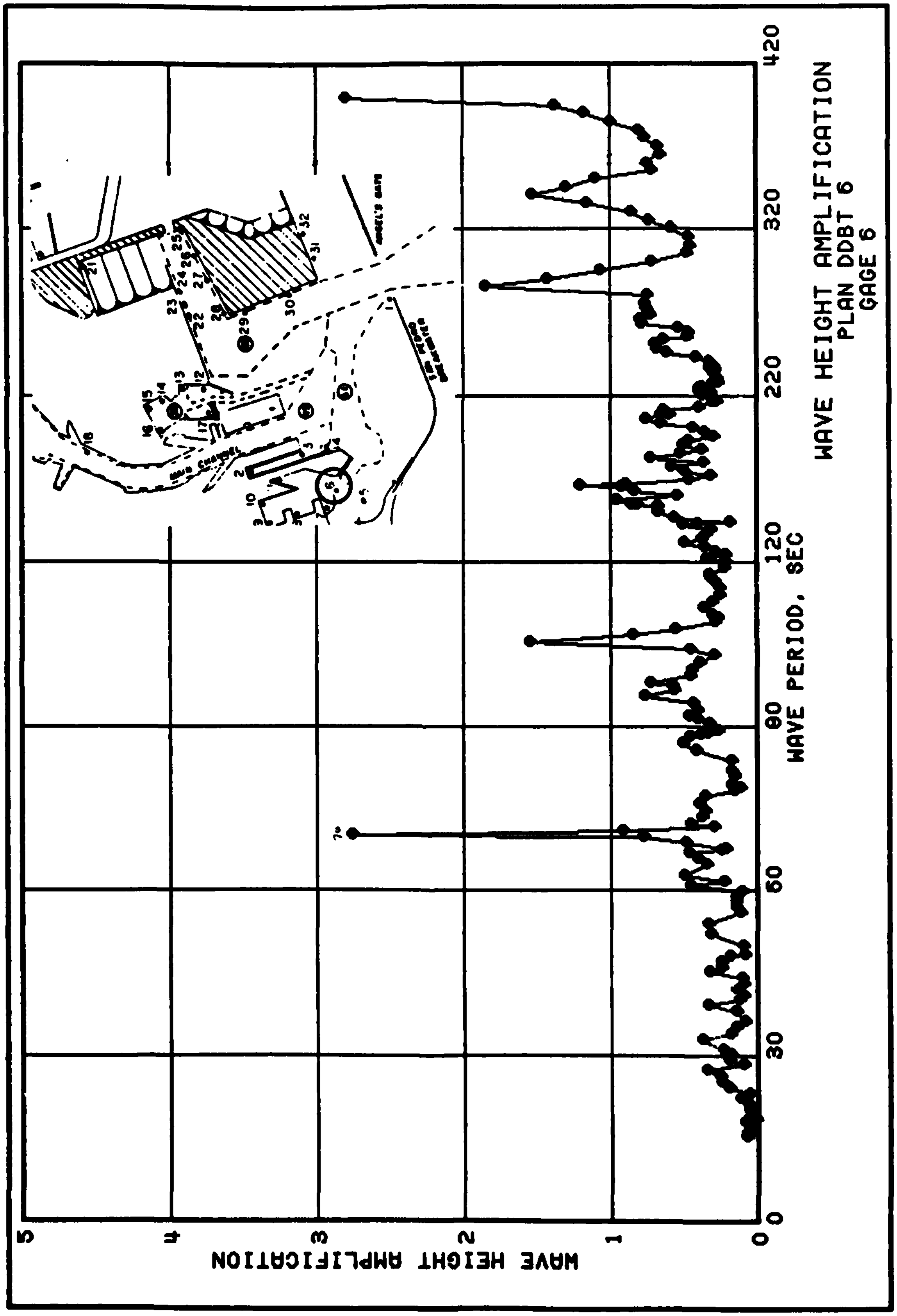
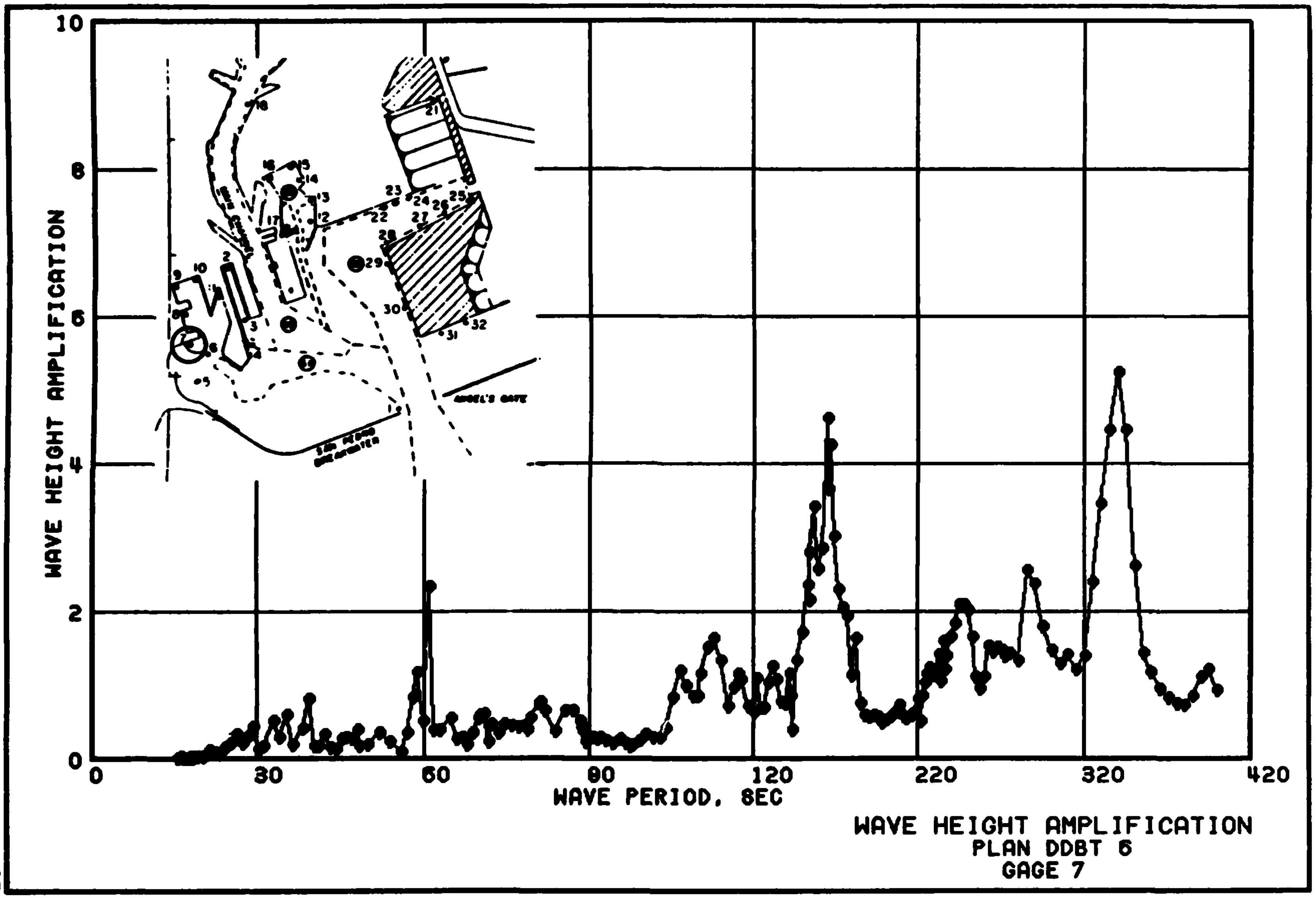
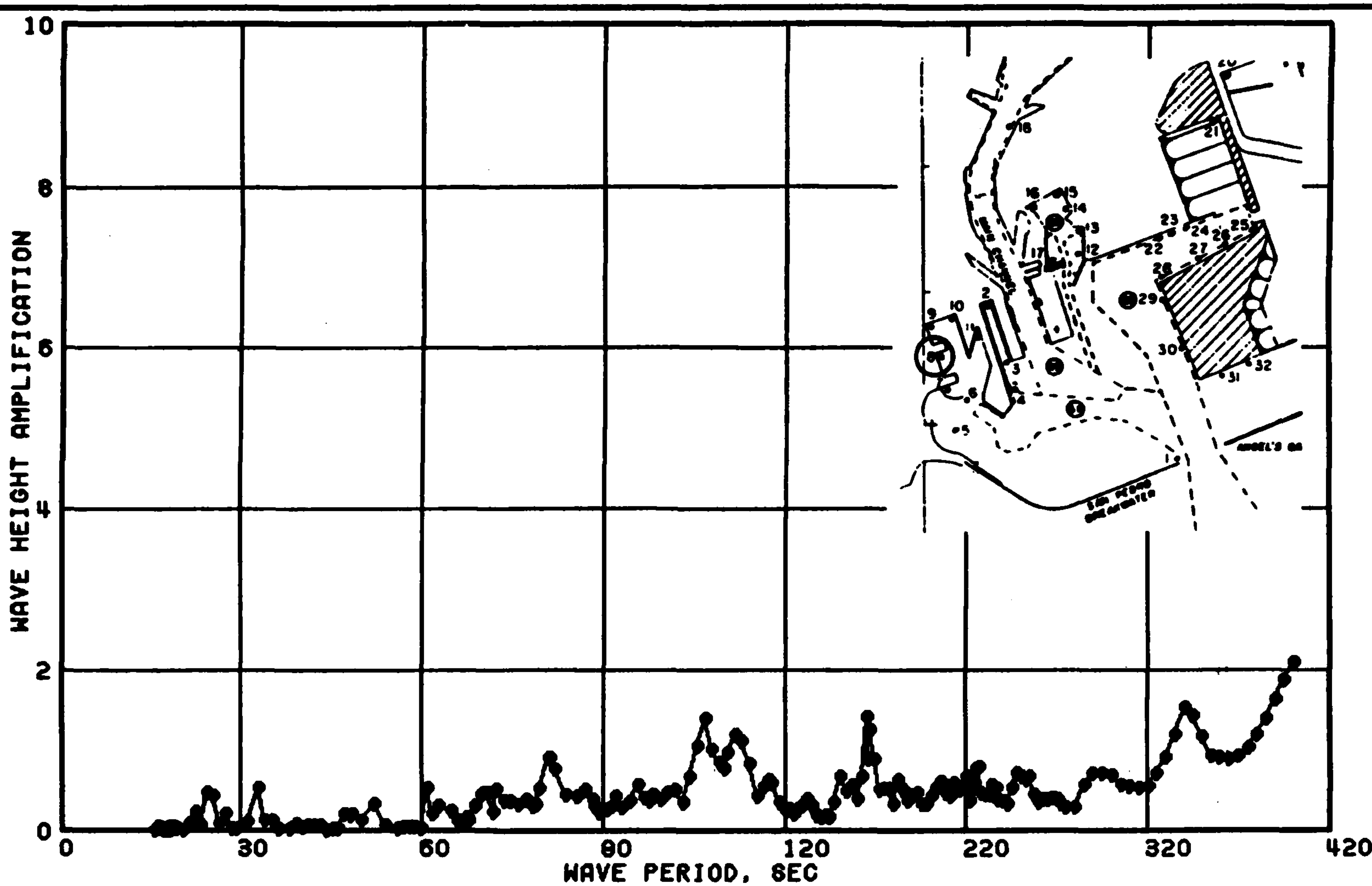
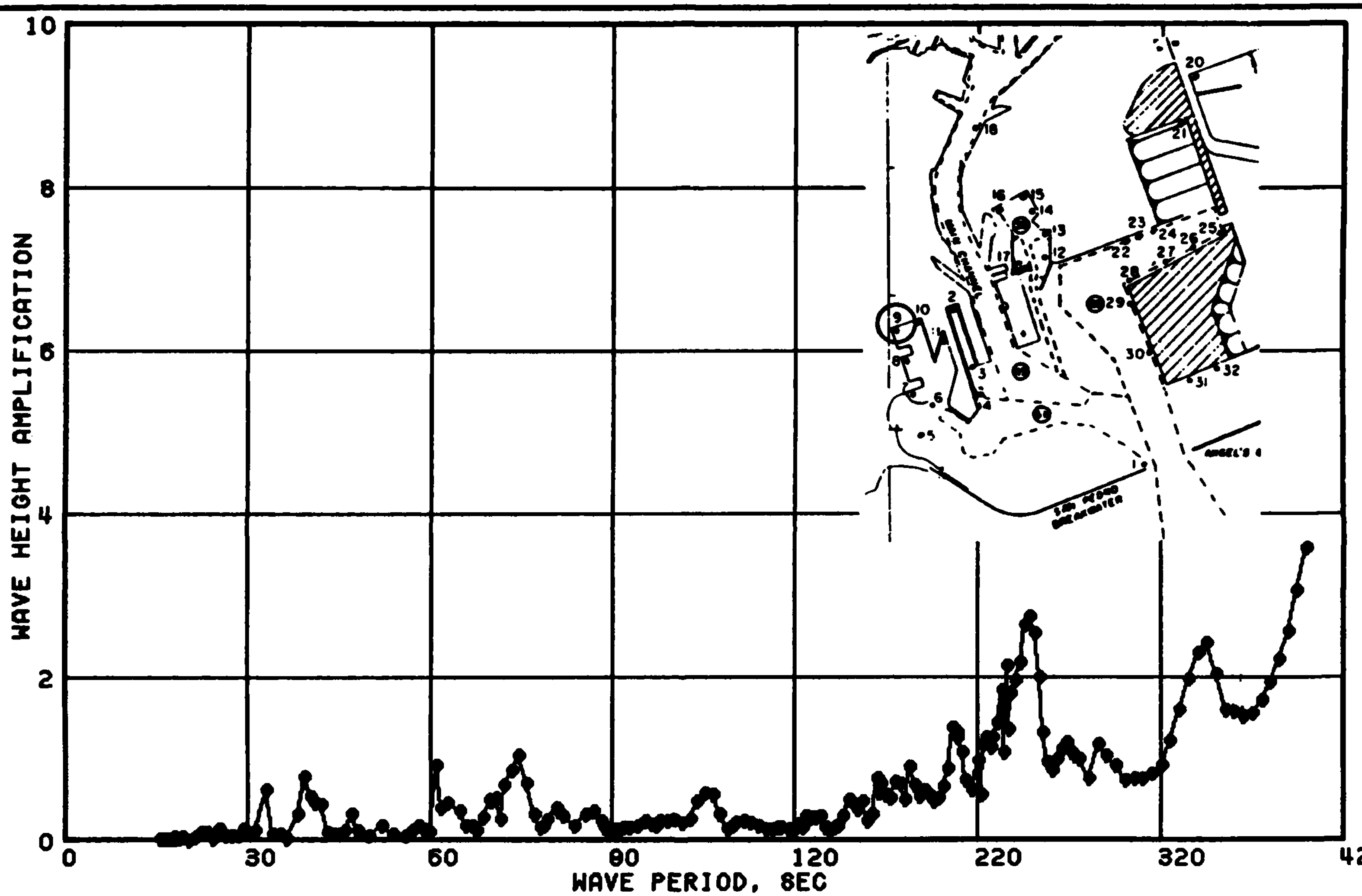

WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 6
WAVE HEIGHT AMPLIFICATION
WAVE PERIOD, SEC
0
30
60
90
120
220
320
420
0
1
2
3
4
5

PLATE 126


WAVE HEIGHT AMPLIFICATION
10
8
6
4
2
0
0
30
60
90
120
220
320
420
WAVE PERIOD, SEC
ANGEL'S GATE
WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 7



WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 8



WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 9

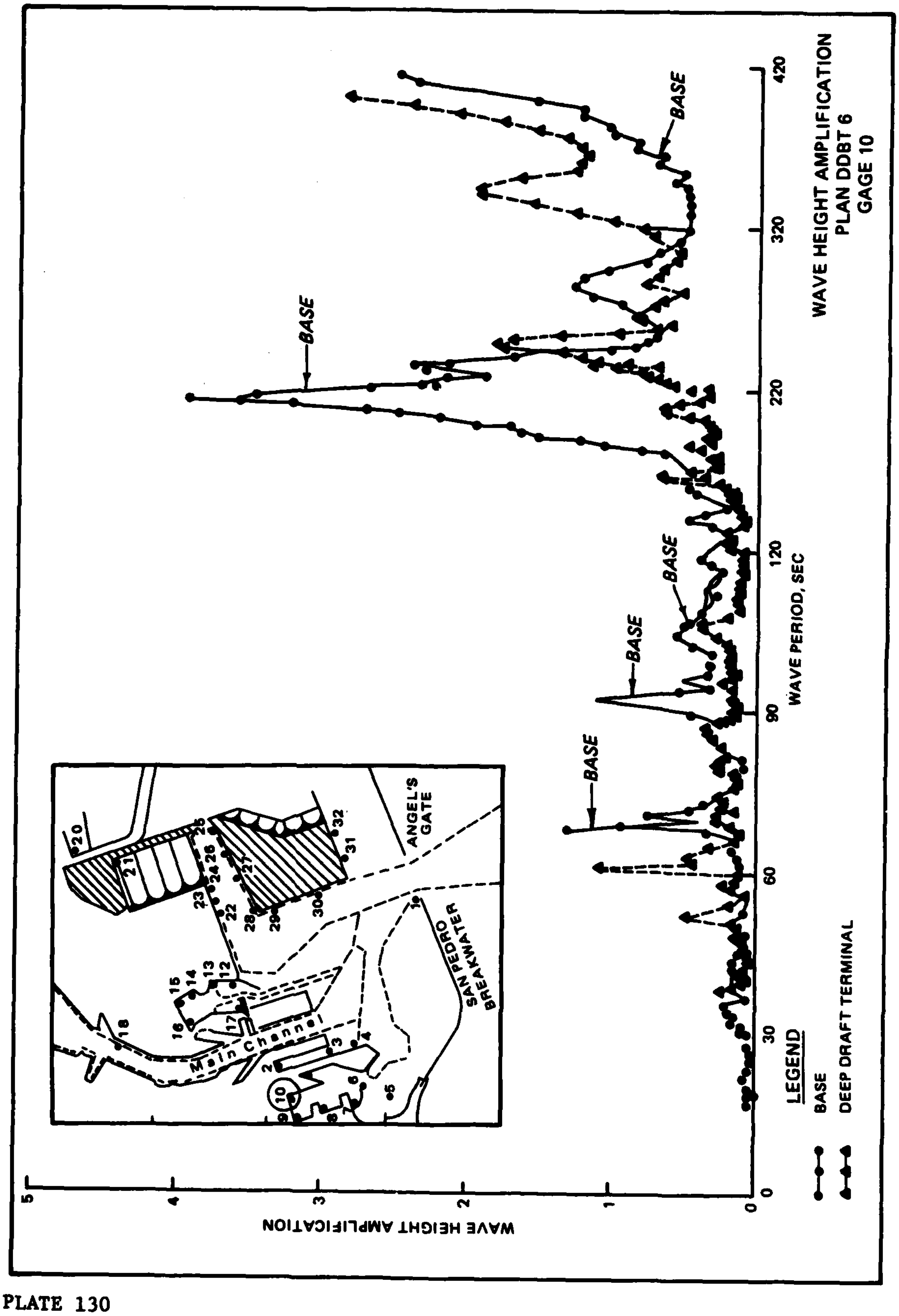
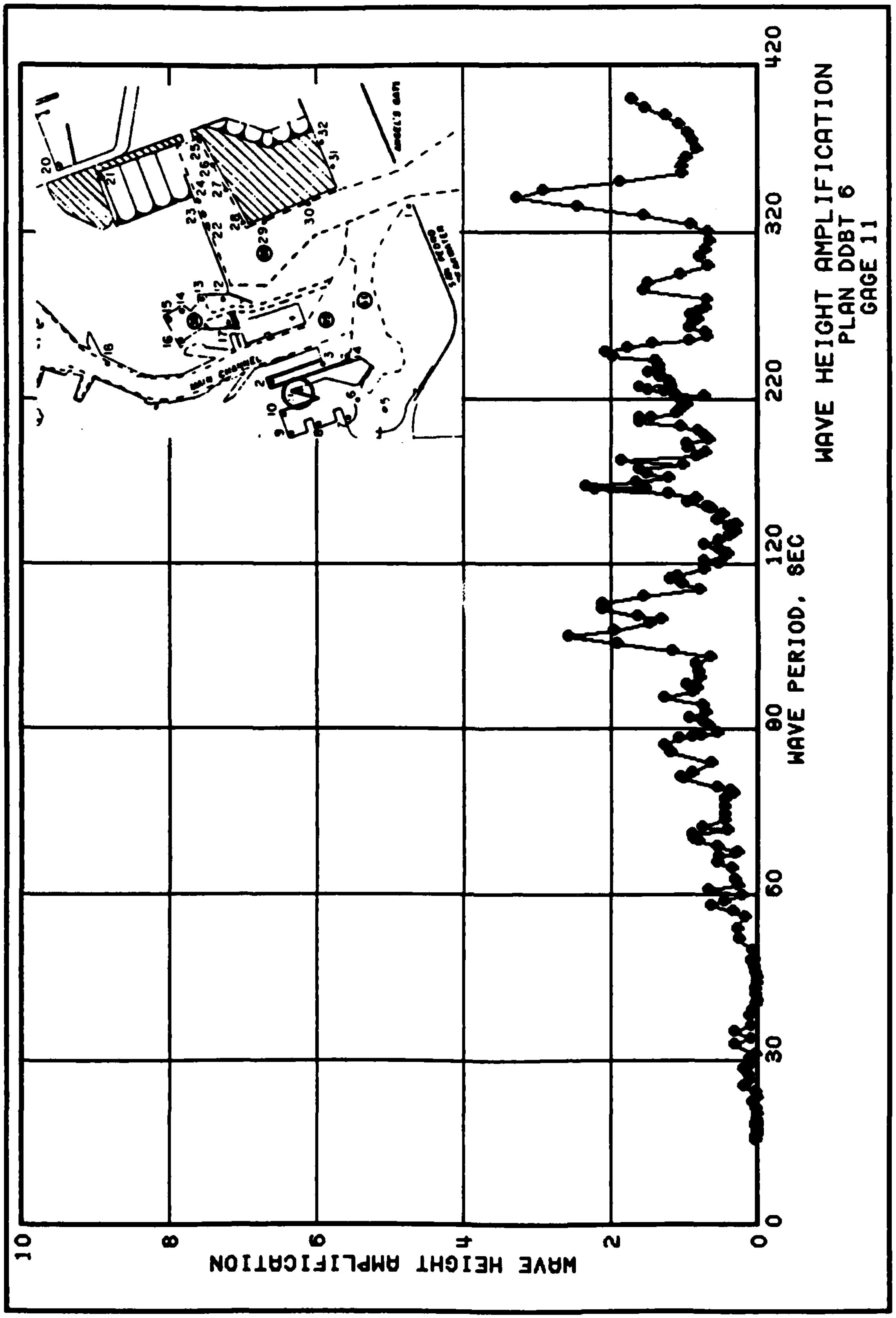

WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 10
WAVE HEIGHT AMPLIFICATION
WAVE PERIOD, SEC
0
30
60
90
120
220
320
420
1
2
3
4
5
BASE
BASE
BASE
BASE
BASE
LEGEND
BASE
DEEP DRAFT TERMINAL
Main Channel
ANGEL'S GATE
SAN PEDRO BREAKWATER

PLATE 130


WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 11
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
0
30
60
90
120
220
320
420
0
2
4
6
8
10

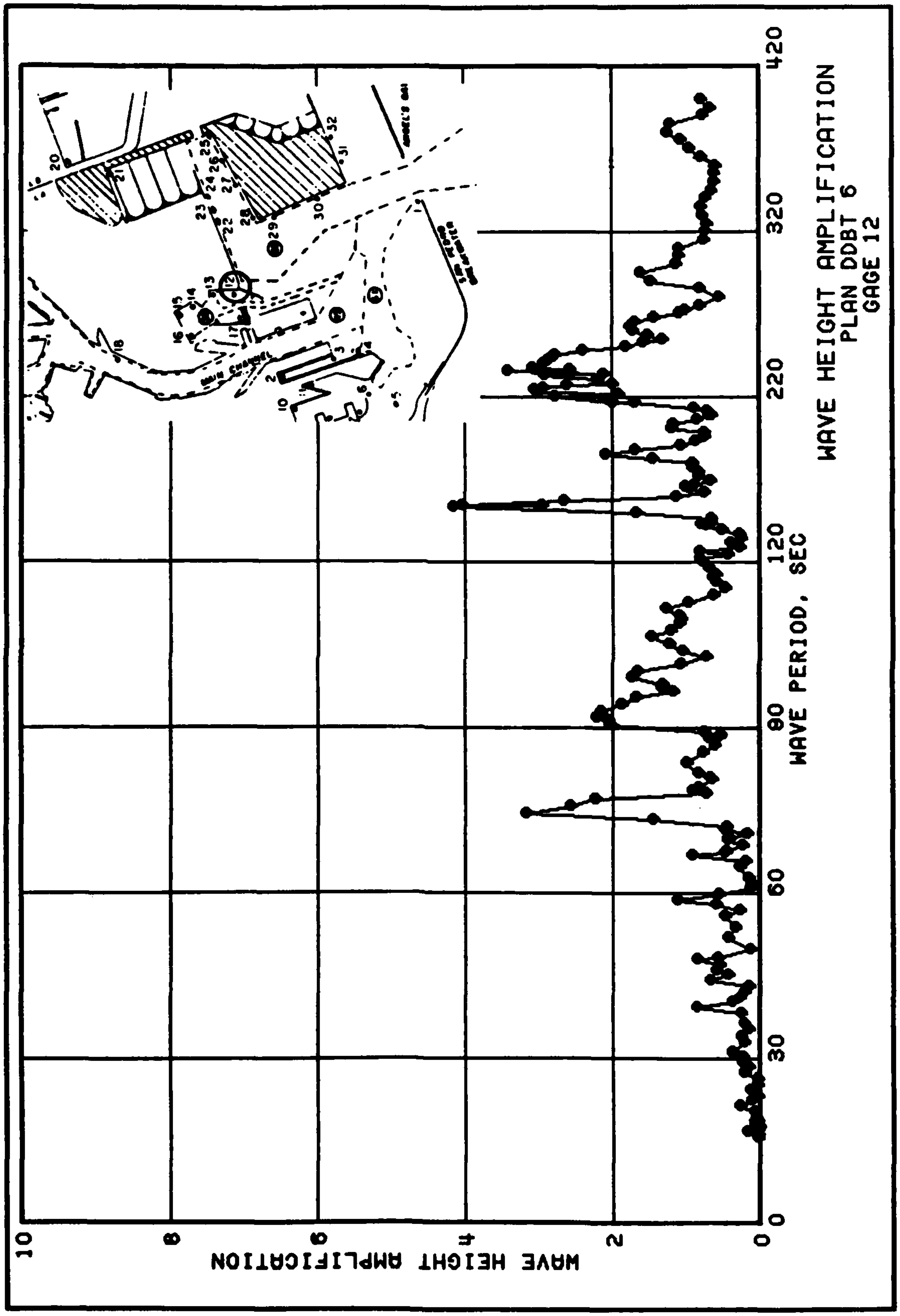
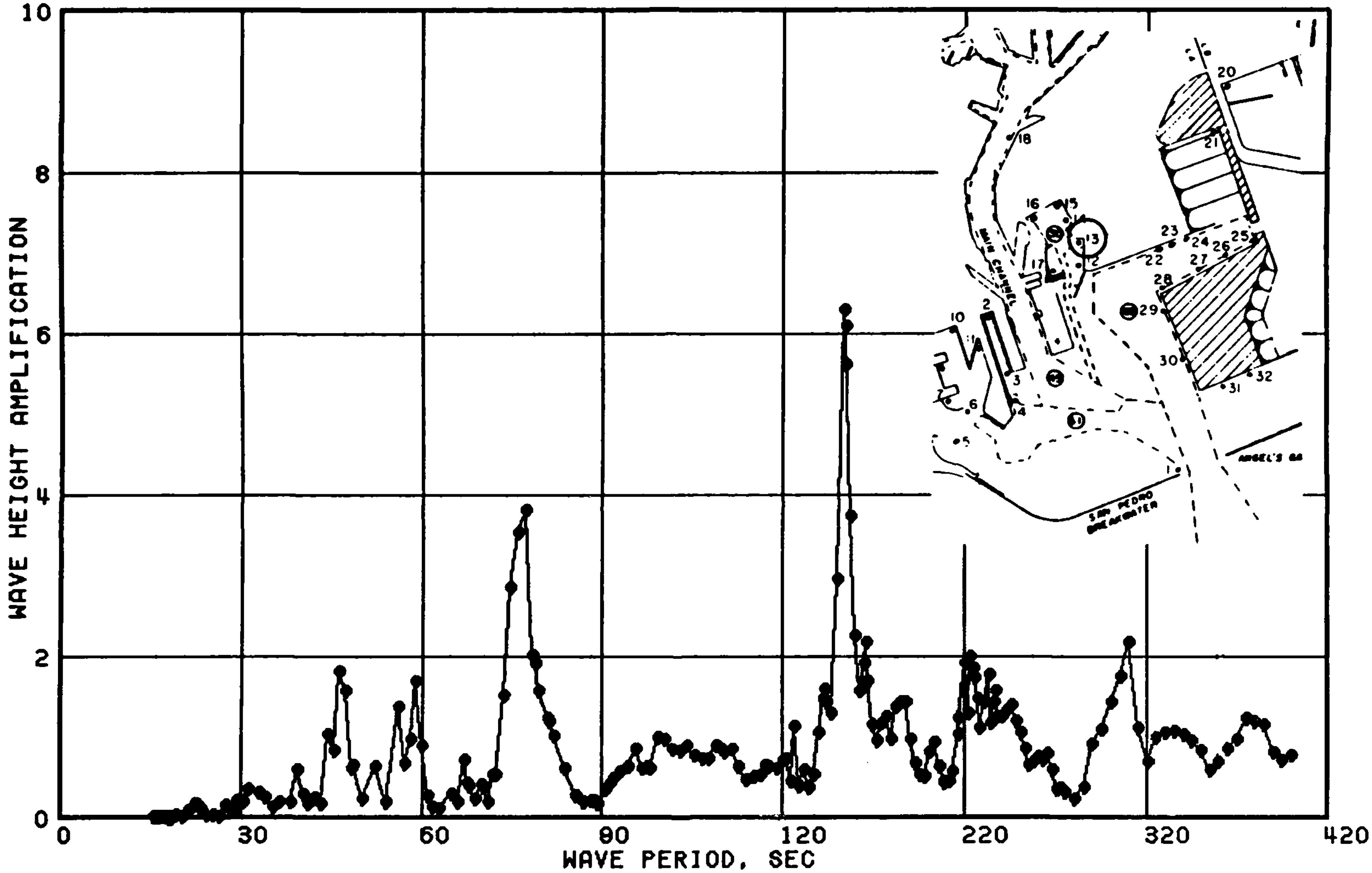
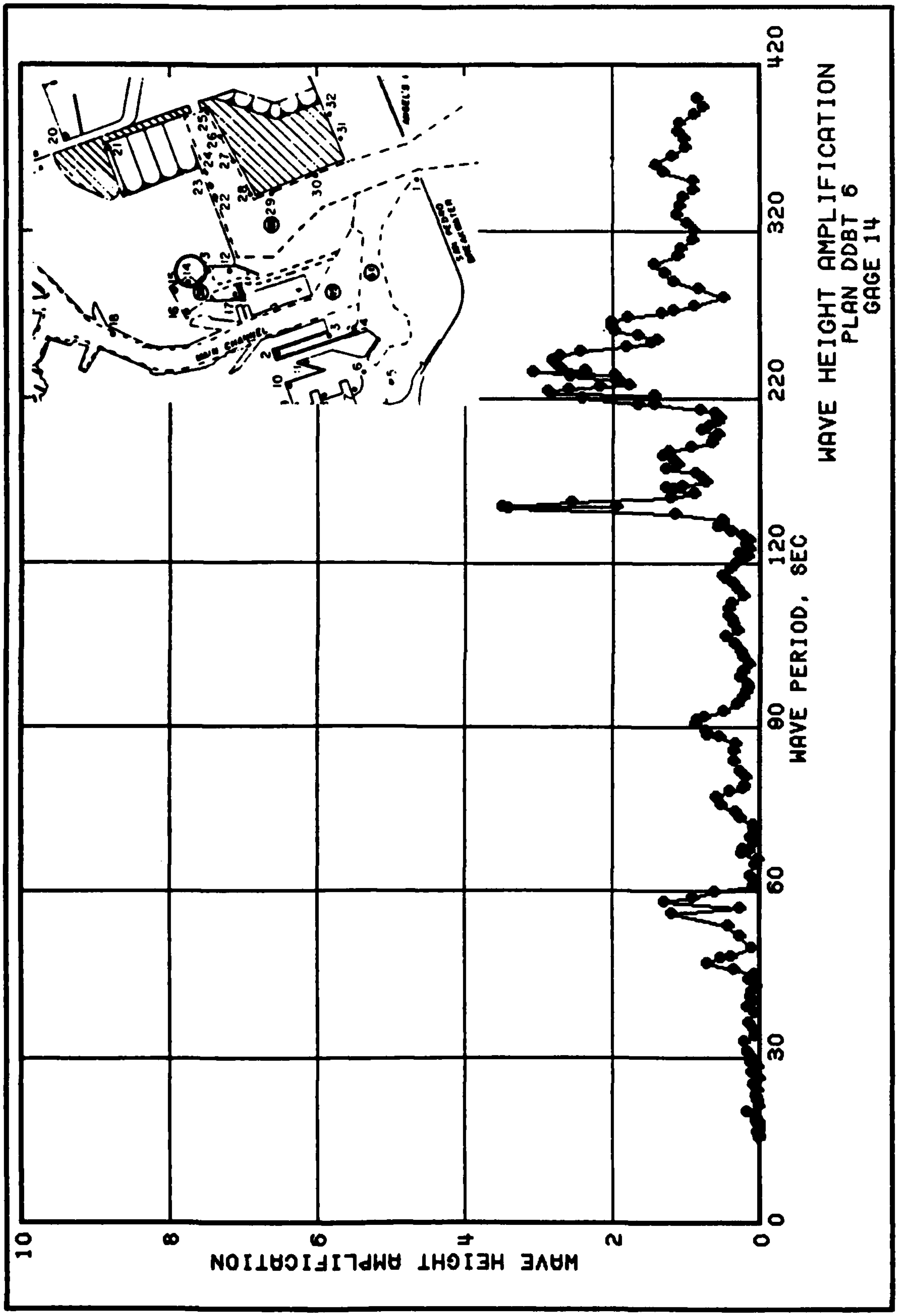

WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 12
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
0
30
60
90
120
220
320
420
0
2
4
6
8
10
MAIN CHANNEL

PLATE 132

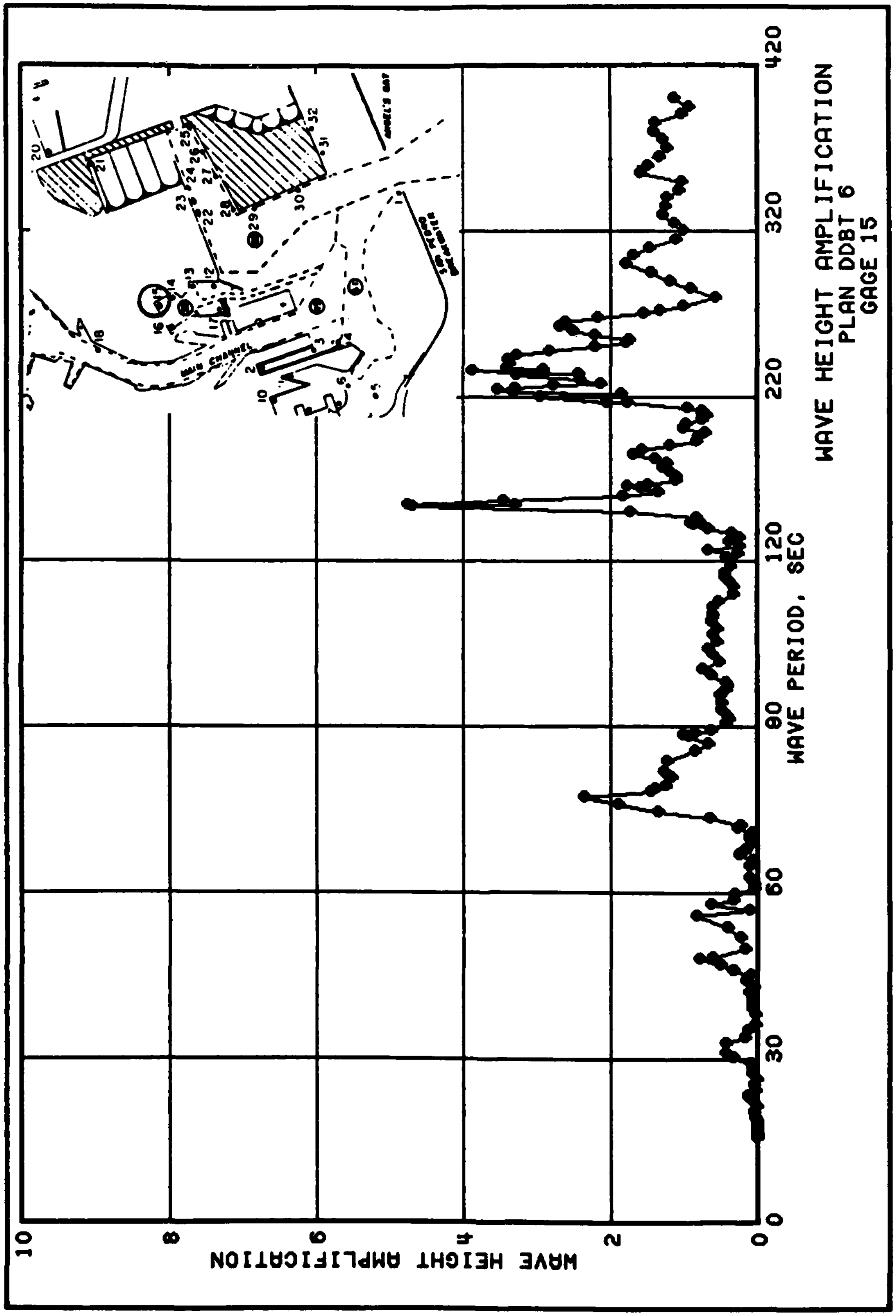


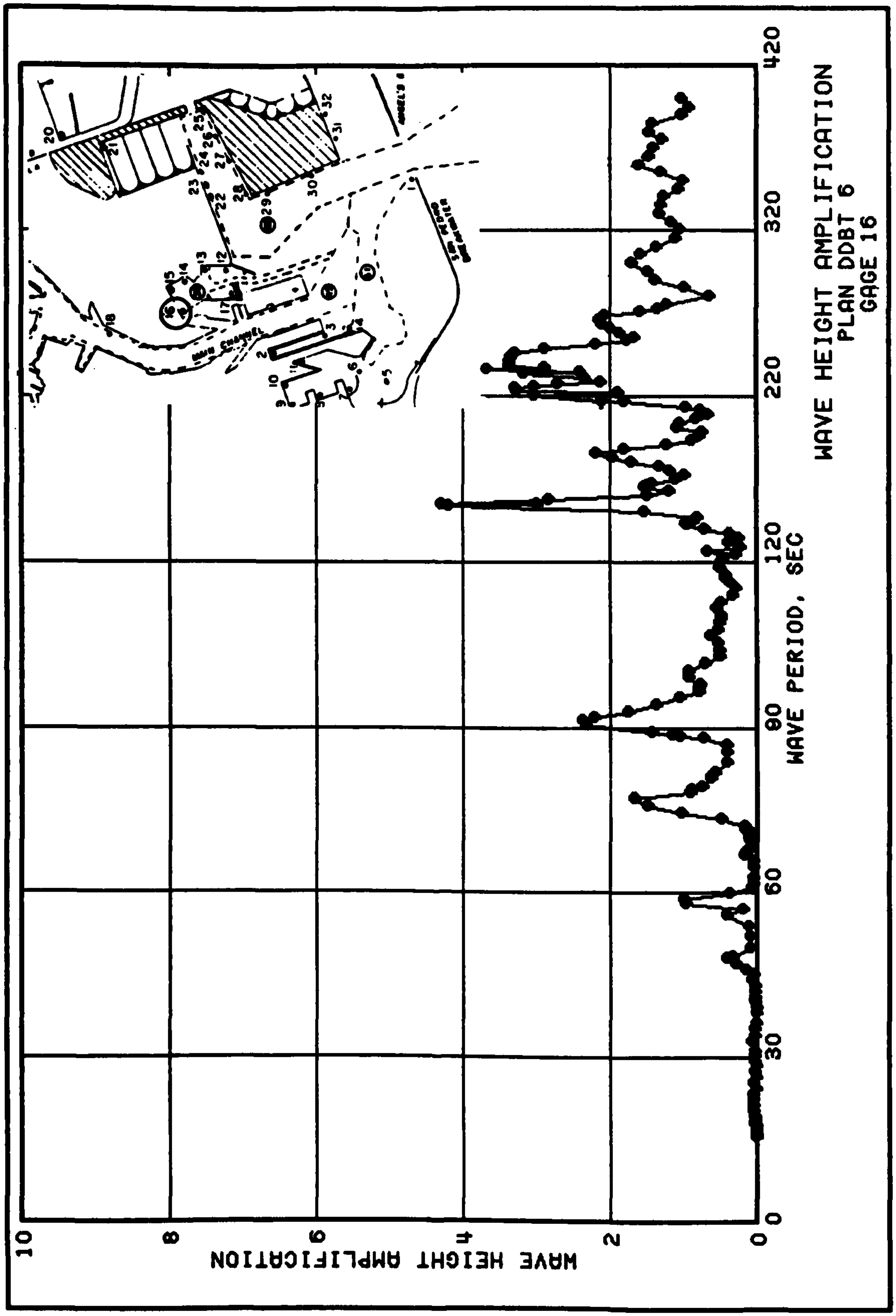
WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 13

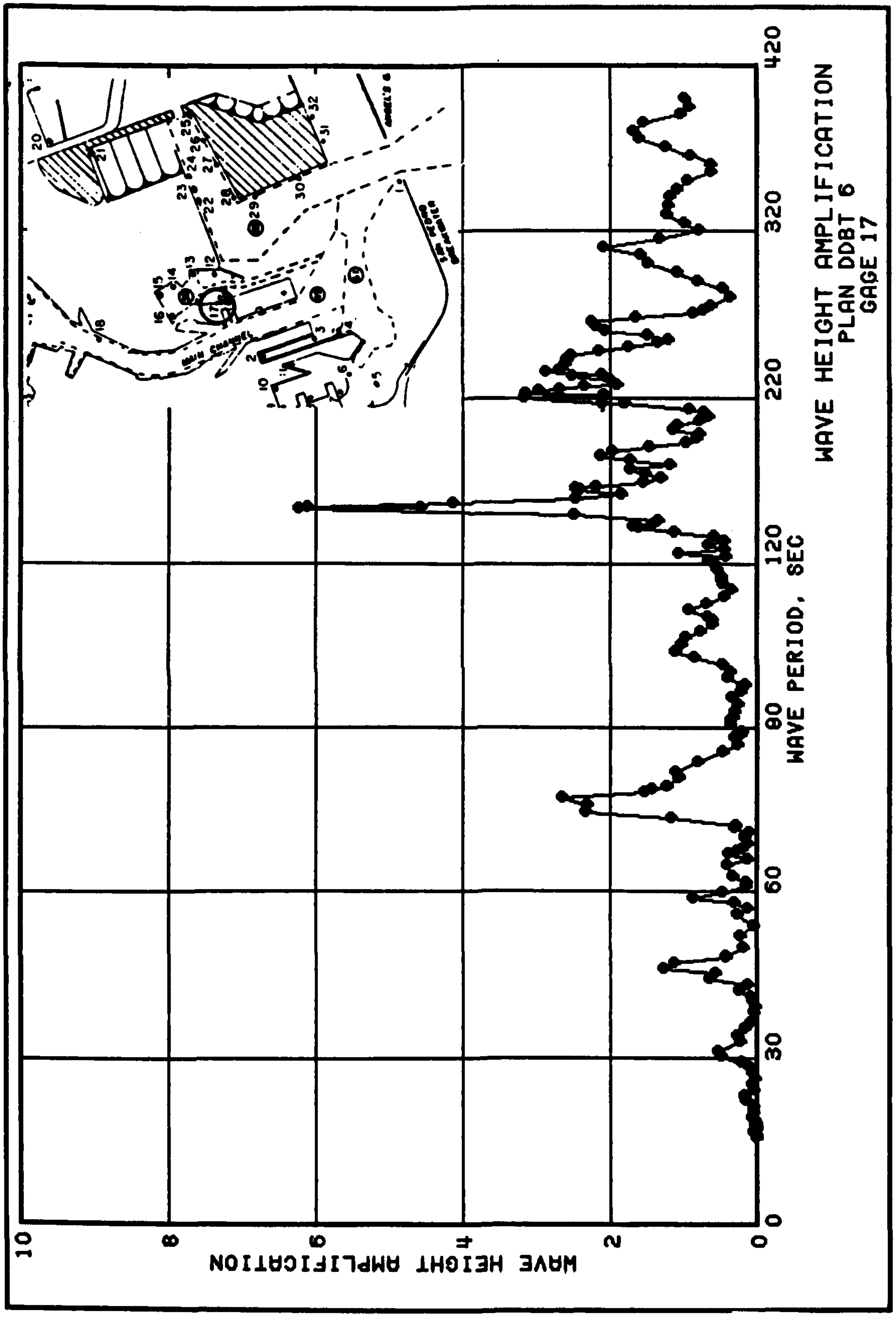


WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 14
WAVE HEIGHT AMPLIFICATION
WAVE PERIOD, SEC
0
30
60
90
120
220
320
420
0
2
4
6
8
10

PLATE 134


WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 15
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
0
30
60
90
120
220
320
420
0
2
4
6
8
10


WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 16
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
0
30
60
90
120
220
320
420
0
2
4
6
8
10



WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 17
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
0
30
60
90
120
220
320
420
0
2
4
6
8
10
MAIN CHANNEL

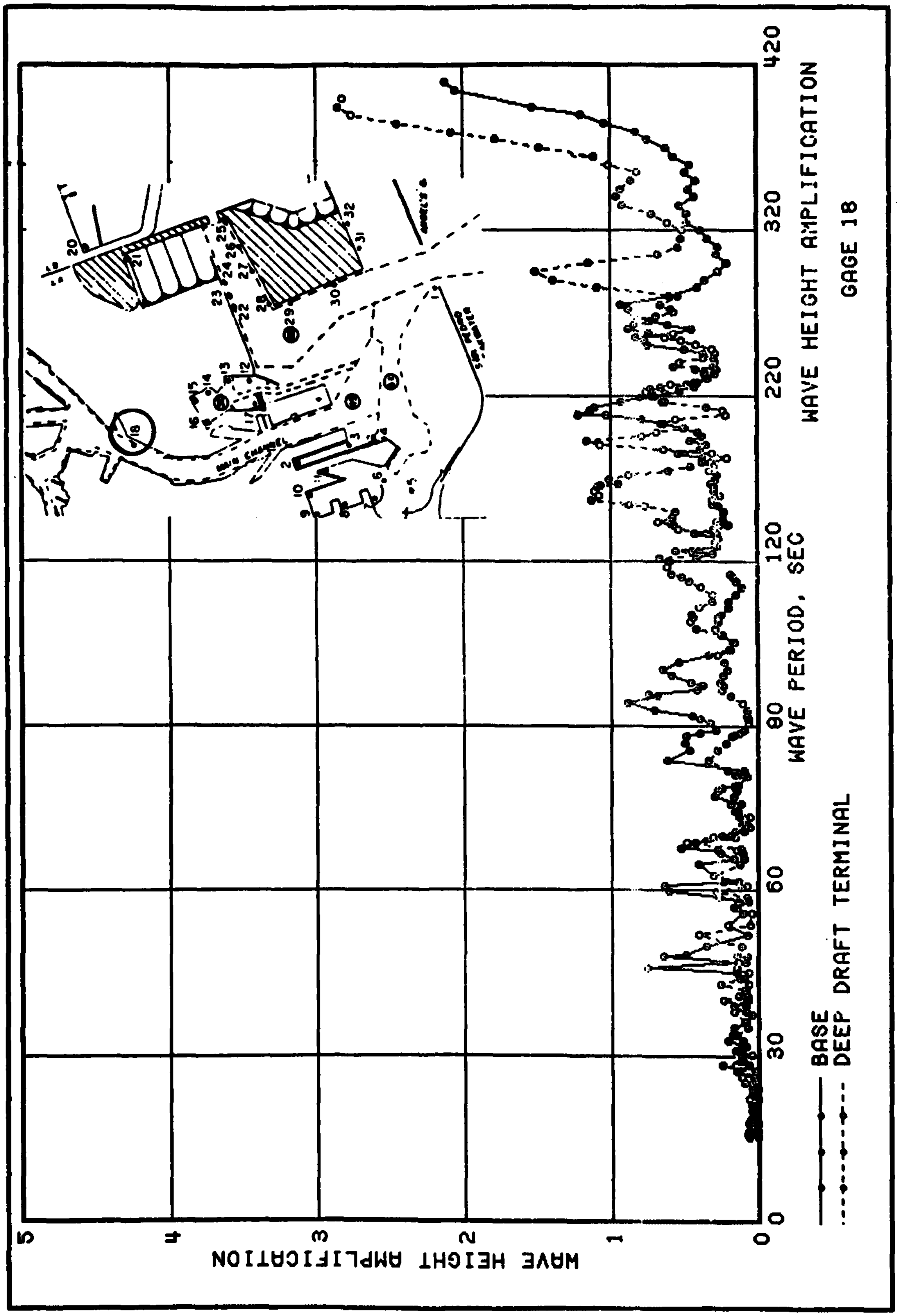
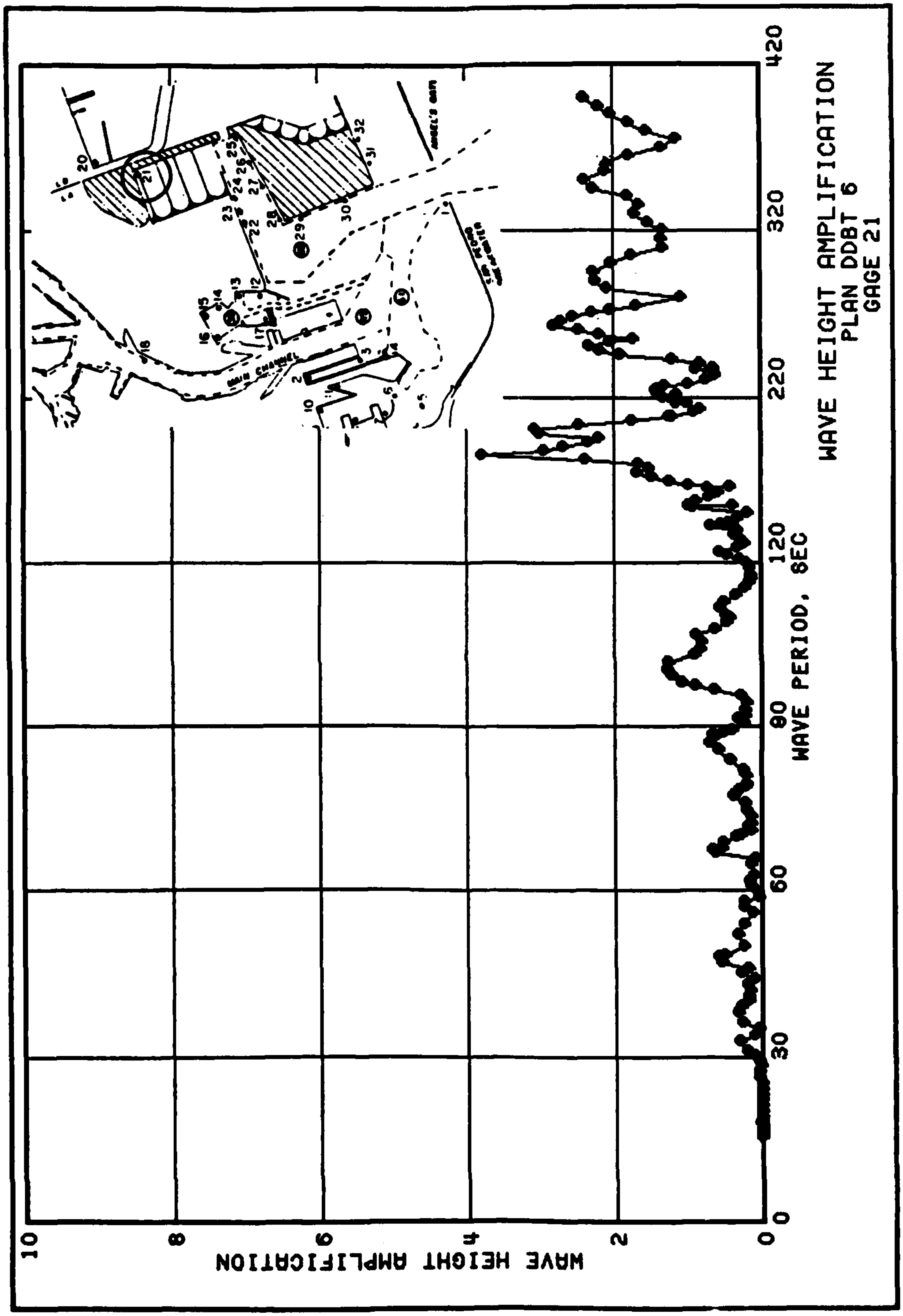
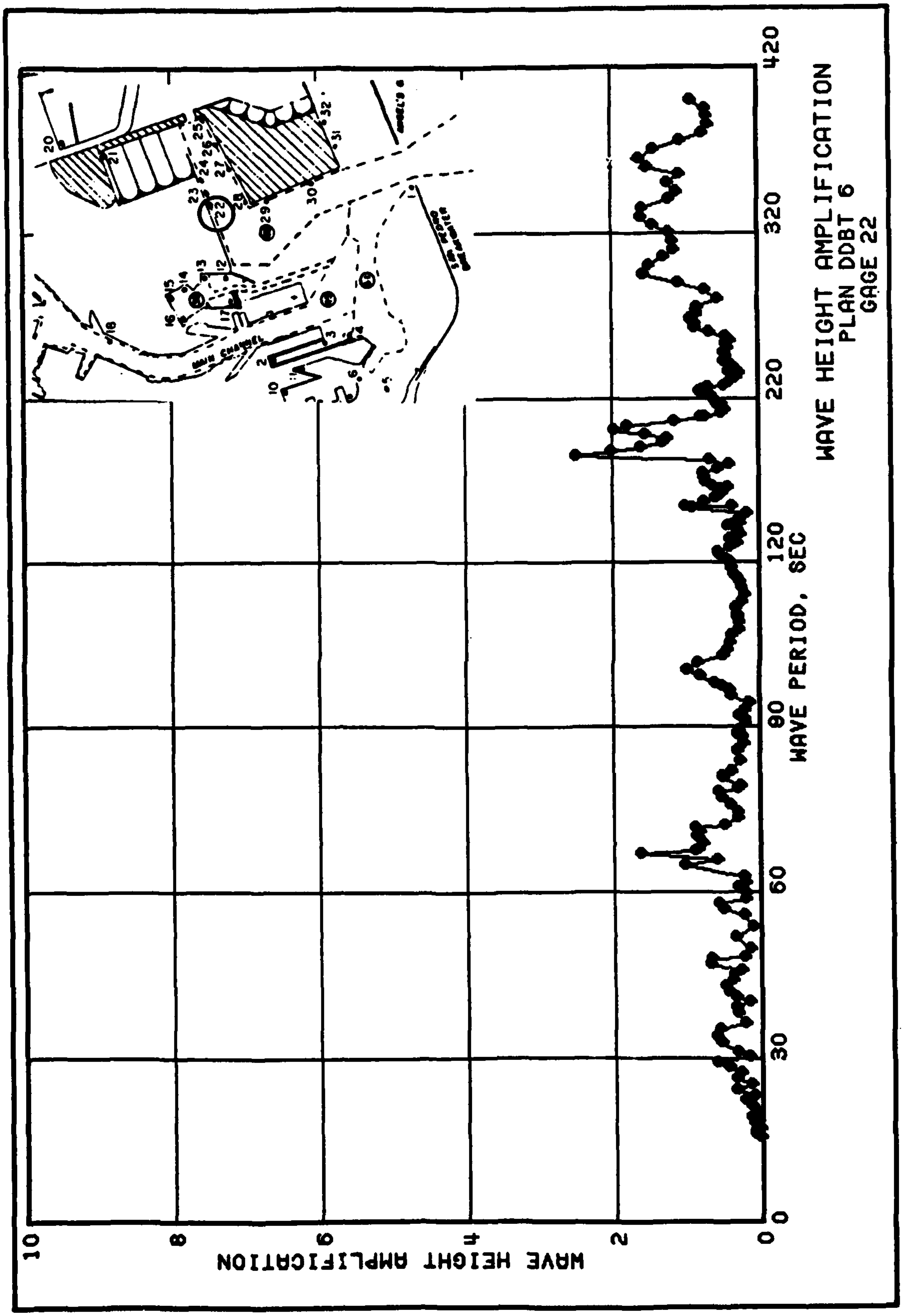
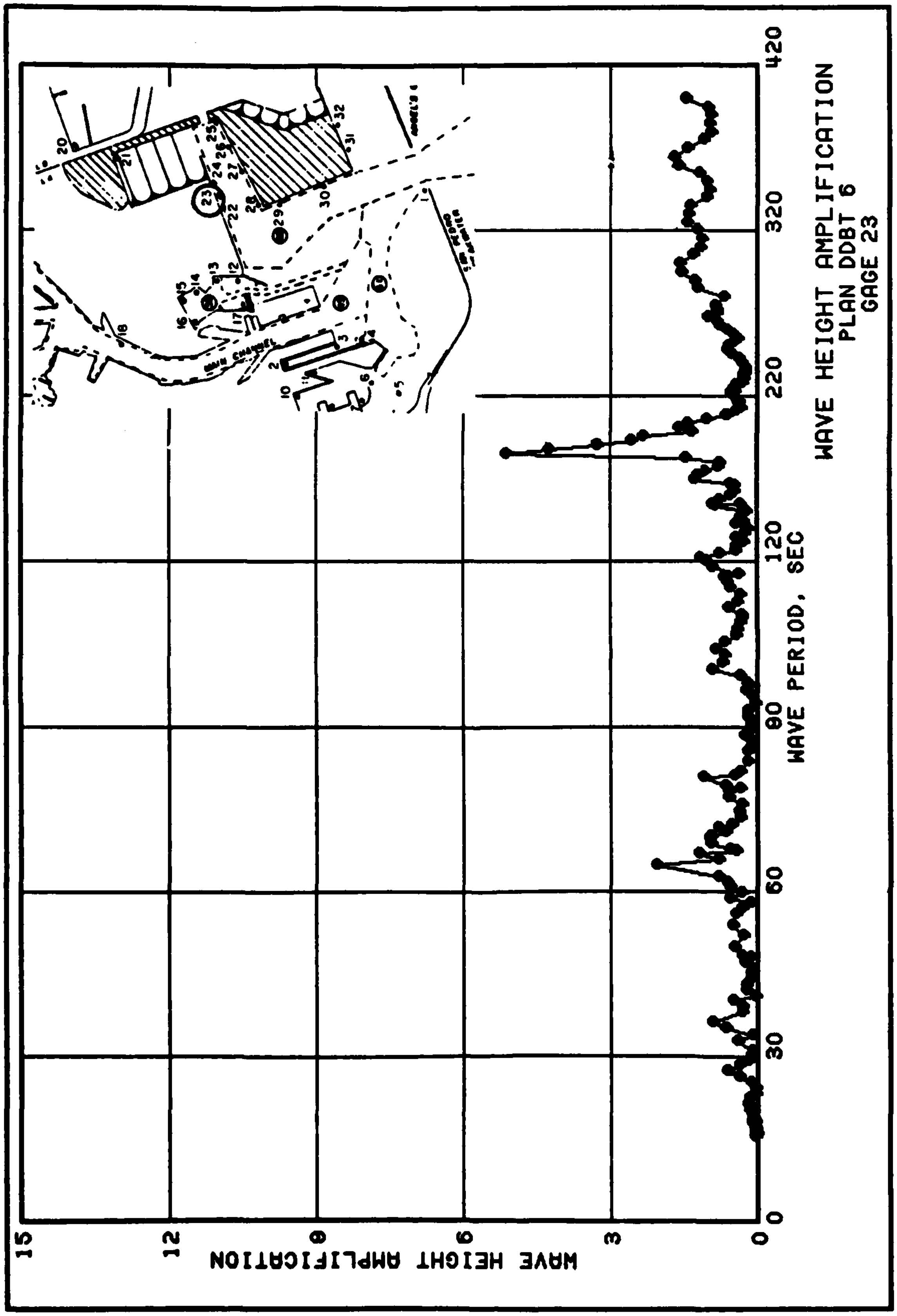

WAVE HEIGHT AMPLIFICATION
GAGE 18
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
0
1
2
3
4
5
0
30
60
90
120
220
320
420
BASE
DEEP DRAFT TERMINAL
MAIN CHANNEL

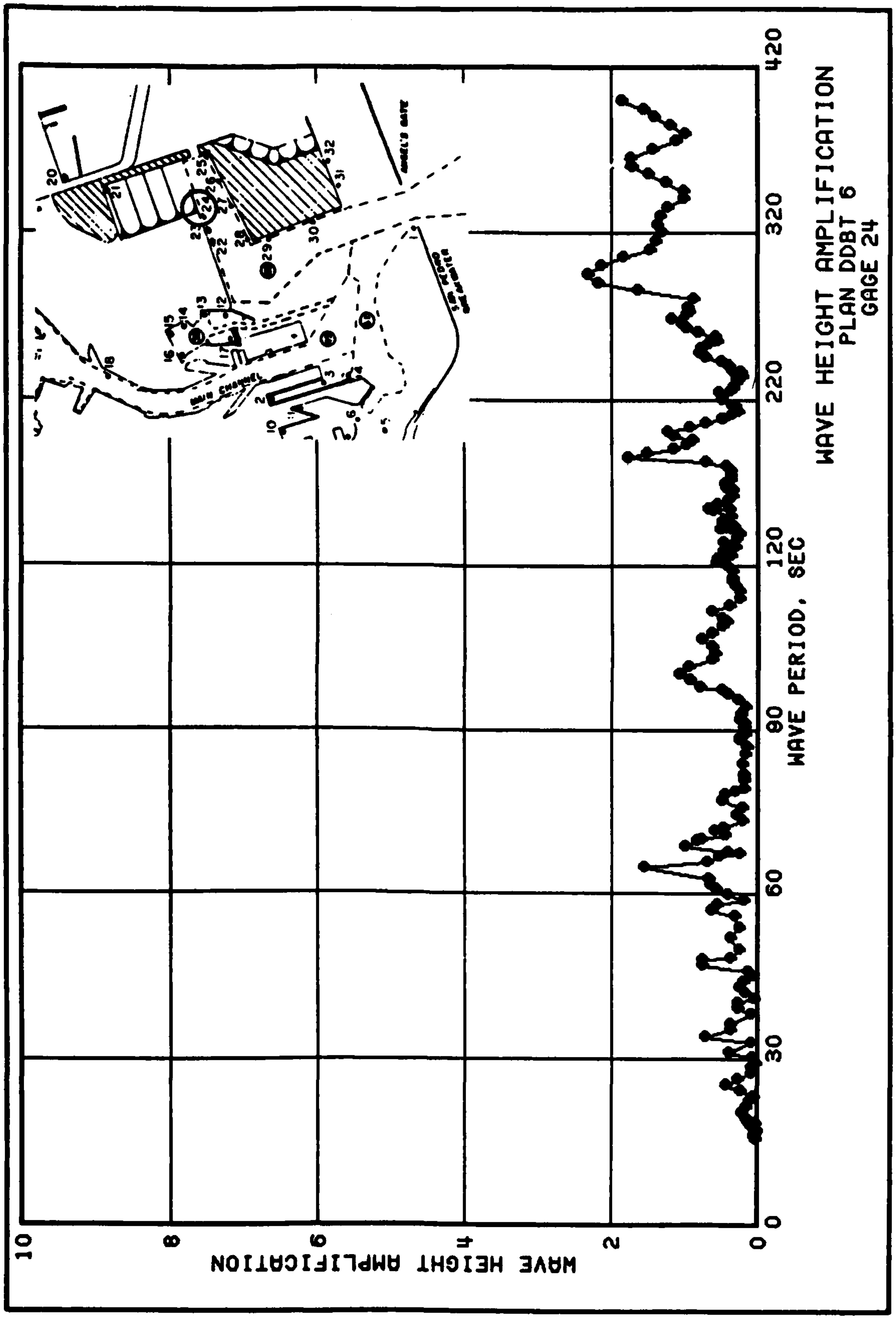
PLATE 138


WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 21
WAVE HEIGHT AMPLIFICATION
WAVE PERIOD, SEC
0
2
4
6
8
10
0
30
60
90
120
220
320
420
MAIN CHANNEL


WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 22
WAVE PERIOD, SEC
0
30
60
90
120
220
320
420
WAVE HEIGHT AMPLIFICATION
0
2
4
6
8
10
MAIN CHANNEL

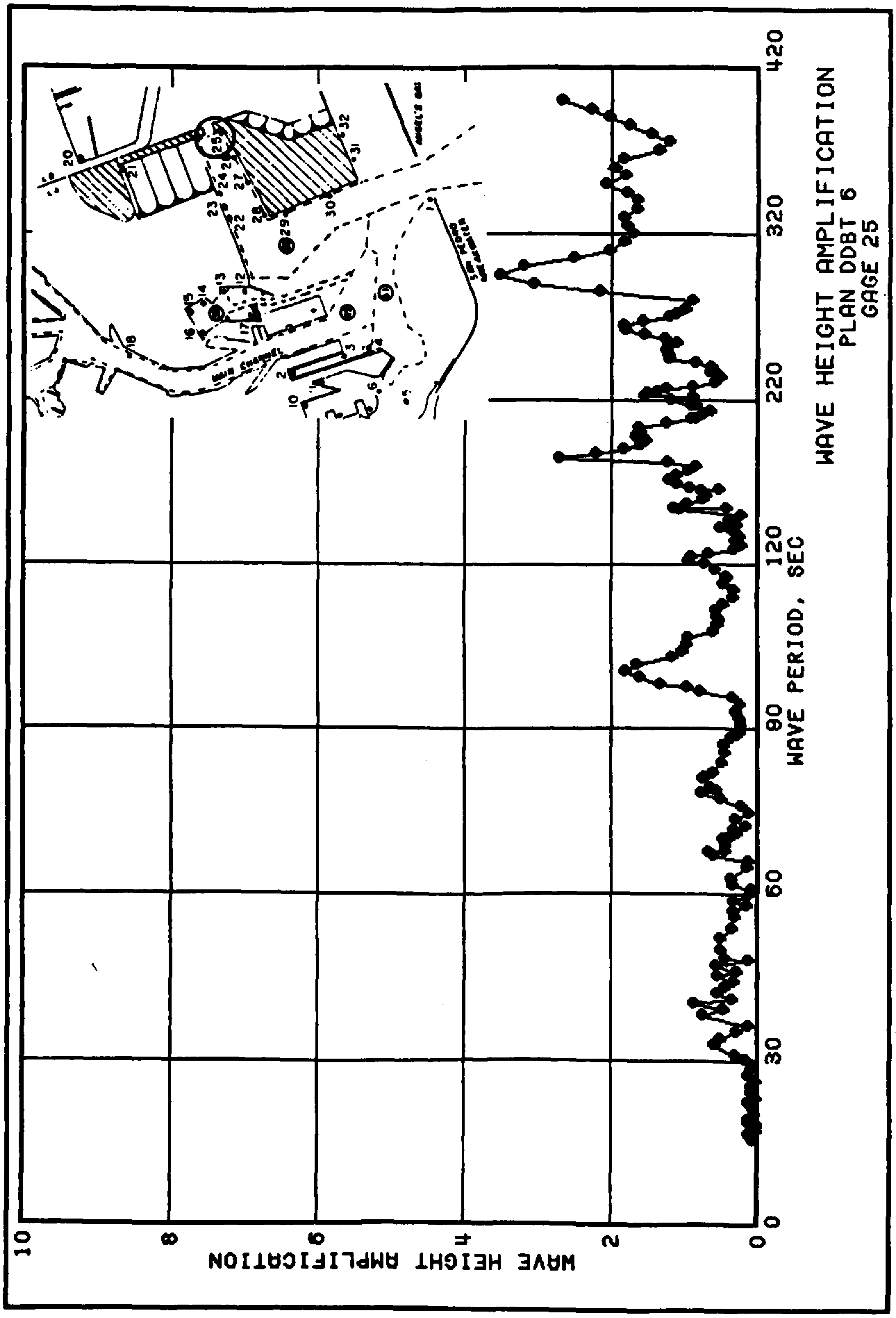


WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 23



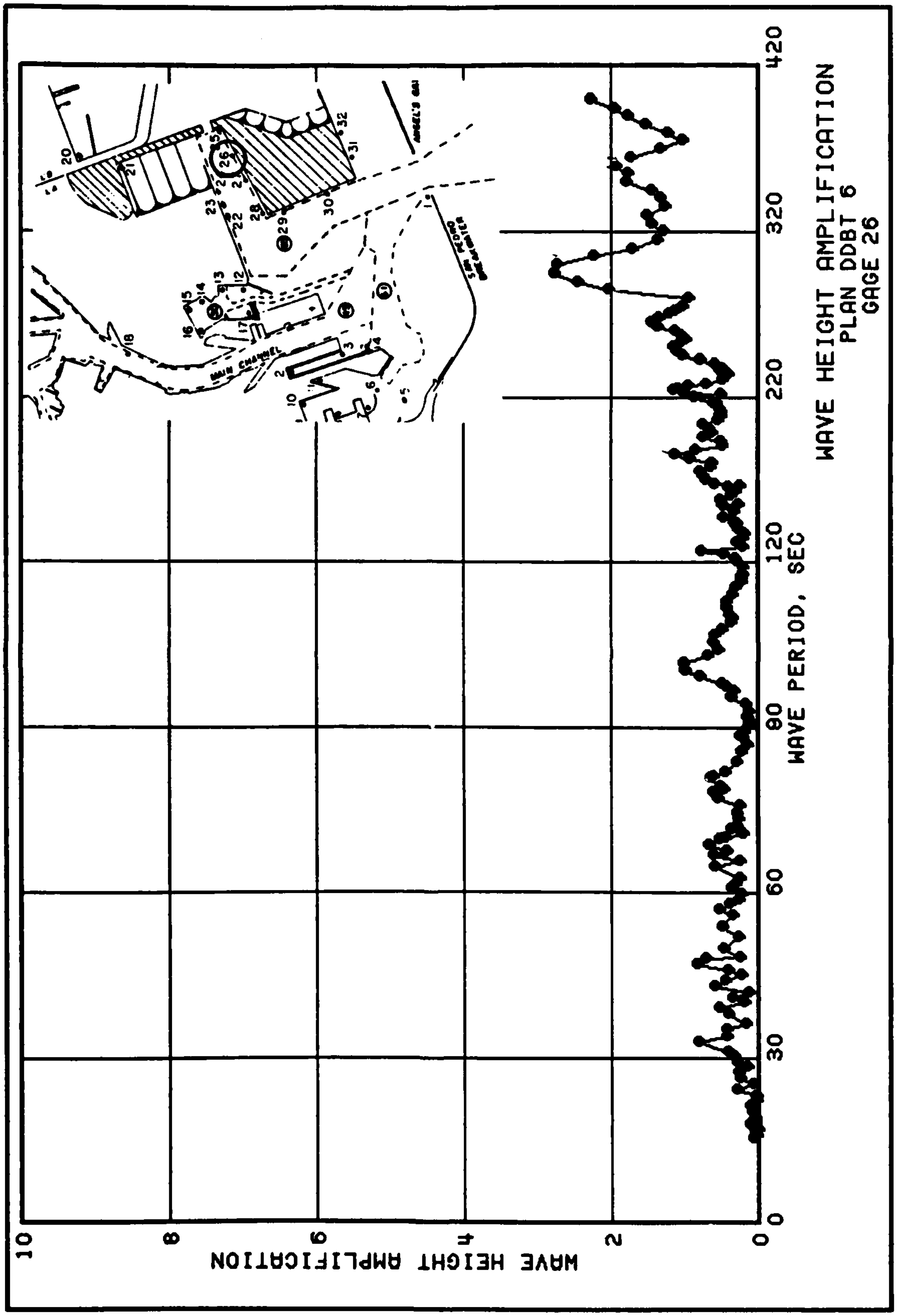
WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 24
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
0
30
60
90
120
220
320
420
0
2
4
6
8
10
MAIN CHANNEL

PLATE 144



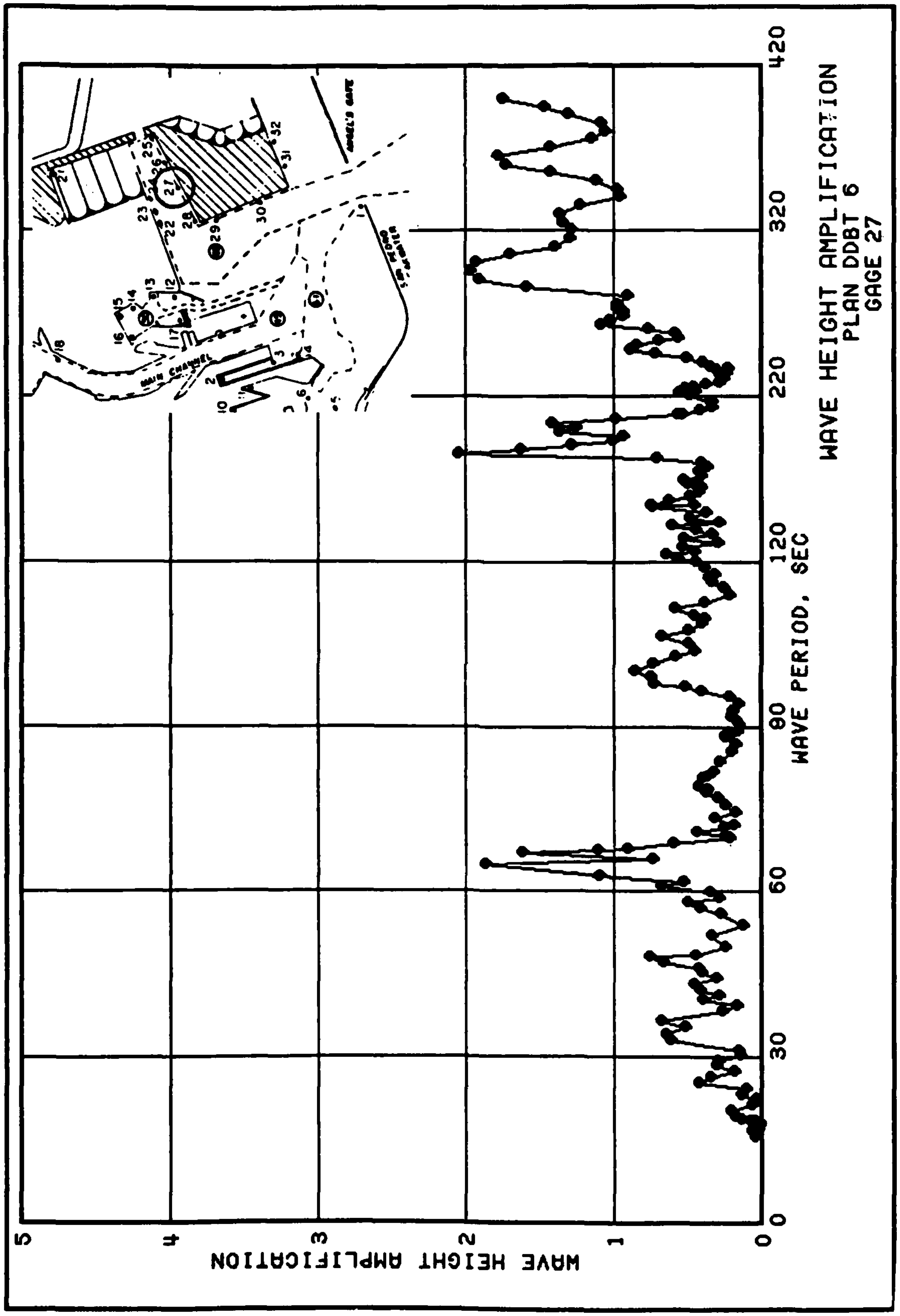
WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 25
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
0
30
60
90
120
220
320
420
0
2
4
6
8
10

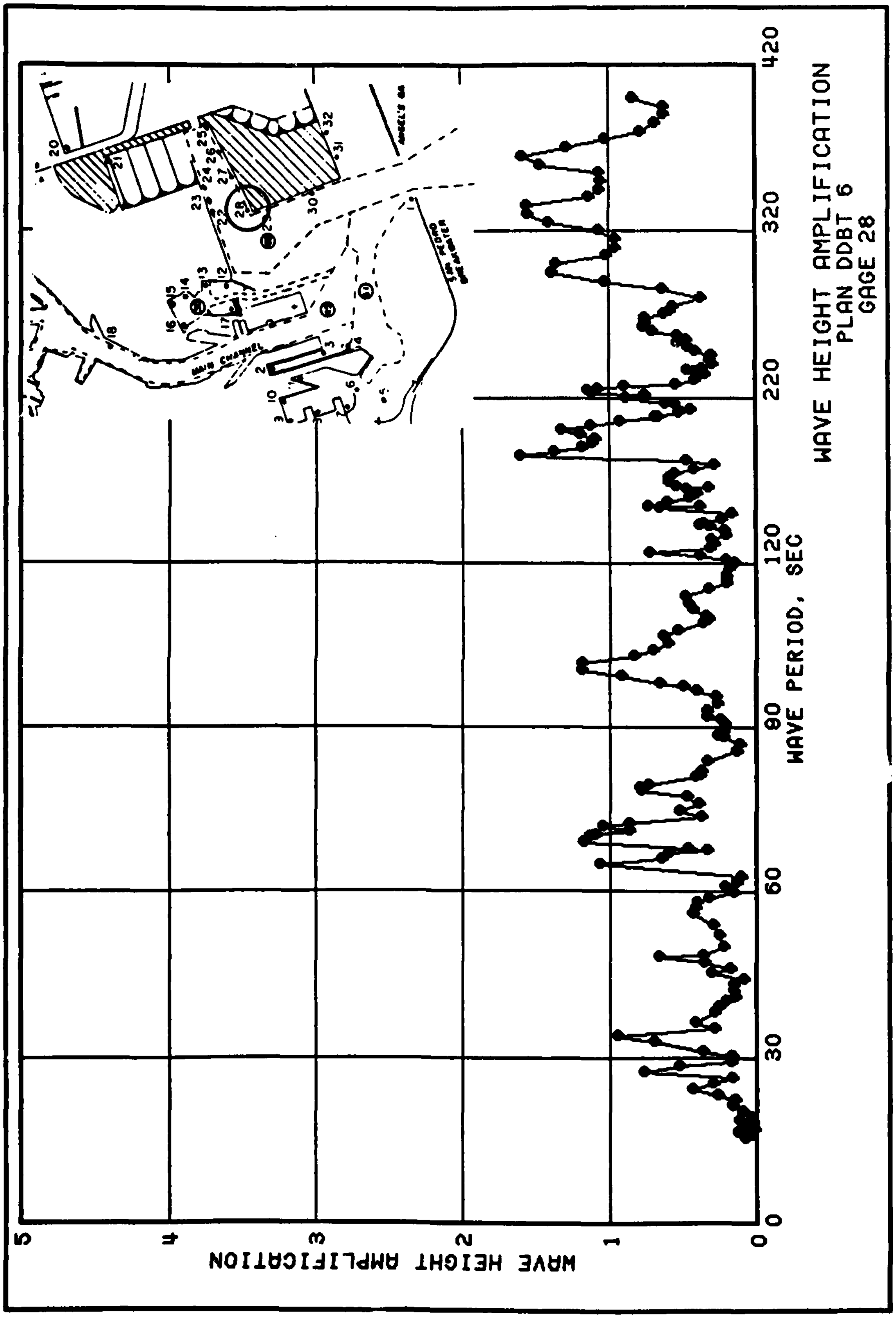
PLATE 145

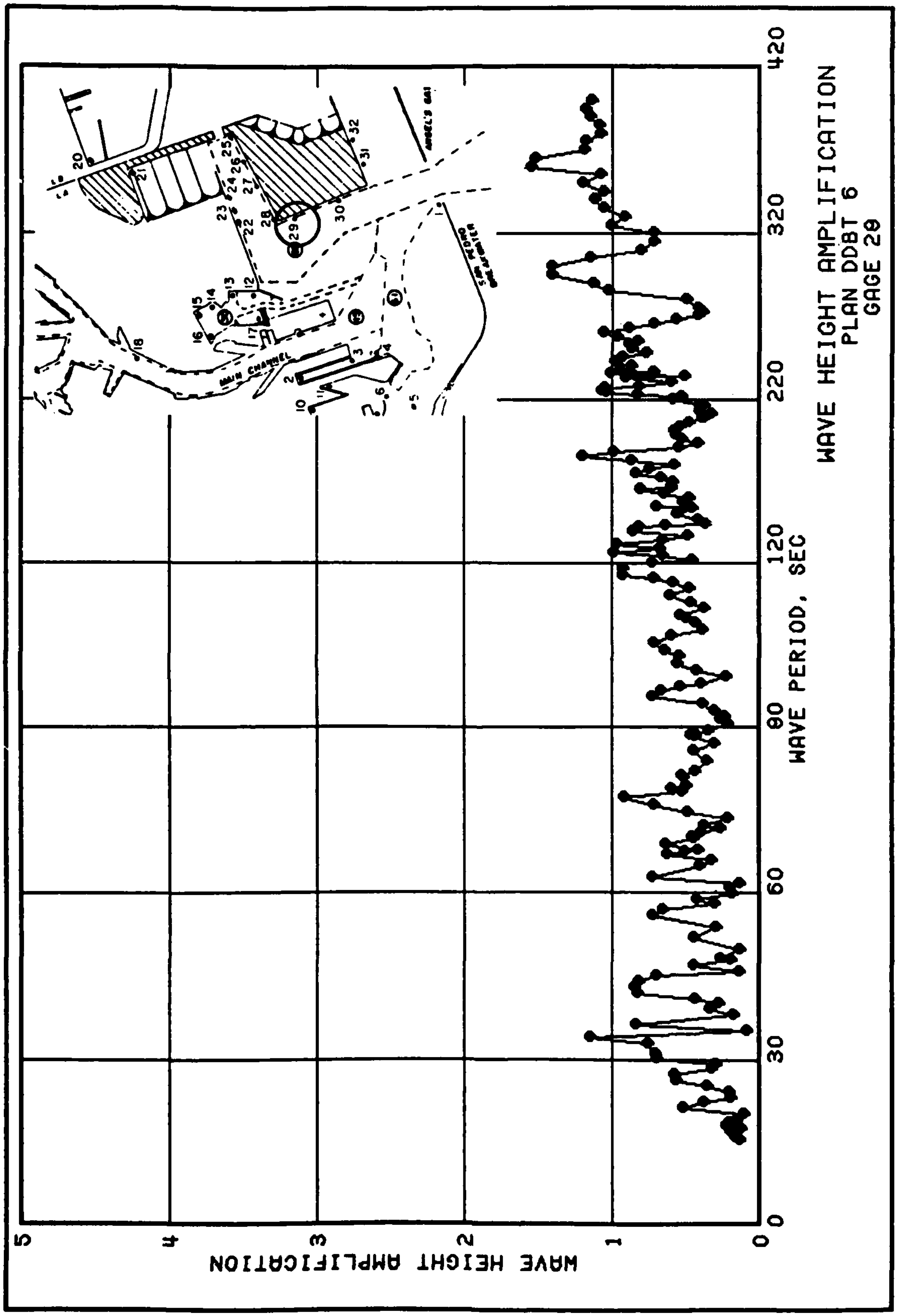


WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 26
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
0
30
60
90
120
220
320
420
0
2
4
6
8
10
MAIN CHANNEL

PLATE 146

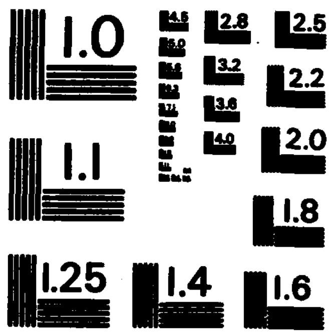

WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 27
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
0
30
60
90
120
220
320
420
0
1
2
3
4
5
MAIN CHANNEL


WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 28
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
0
30
60
90
120
220
320
420
0
1
2
3
4
5
MAIN CHANNEL



WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 29
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
MAIN CHANNEL
SAN PEDRO BREAKWATER
ANGEL'S GATE

AD-A159 448 LOS ANGELES AND LONG BEACH HARBORS MODEL STUDY 3/3
DEEP-DRAFT DRY BULK EXPORT..(U) COASTAL ENGINEERING
RESEARCH CENTER VICKSBURG MS W C SEABERGH JUL 85
UNCLASSIFIED CERC-85-8 F/G 8/3 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

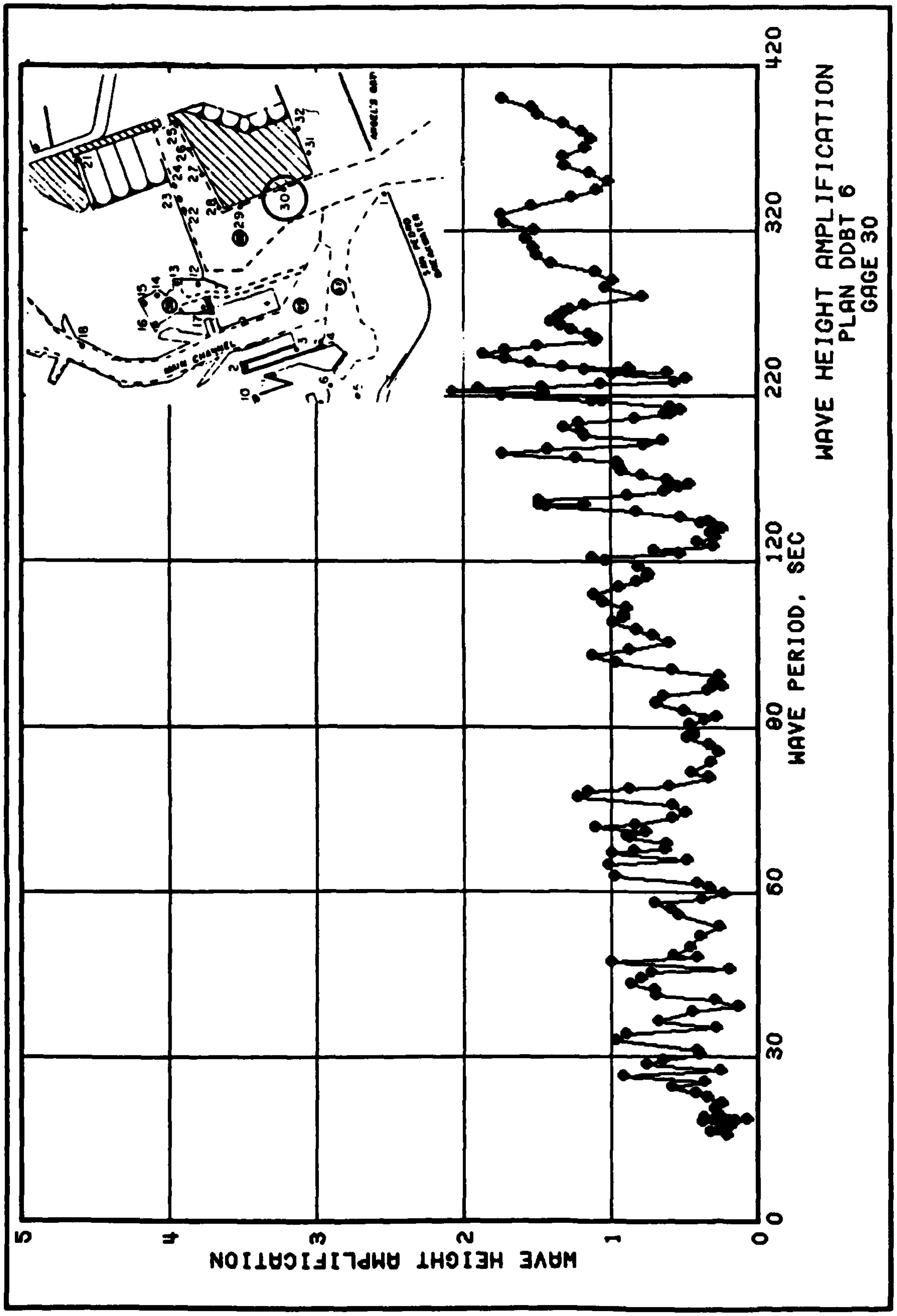
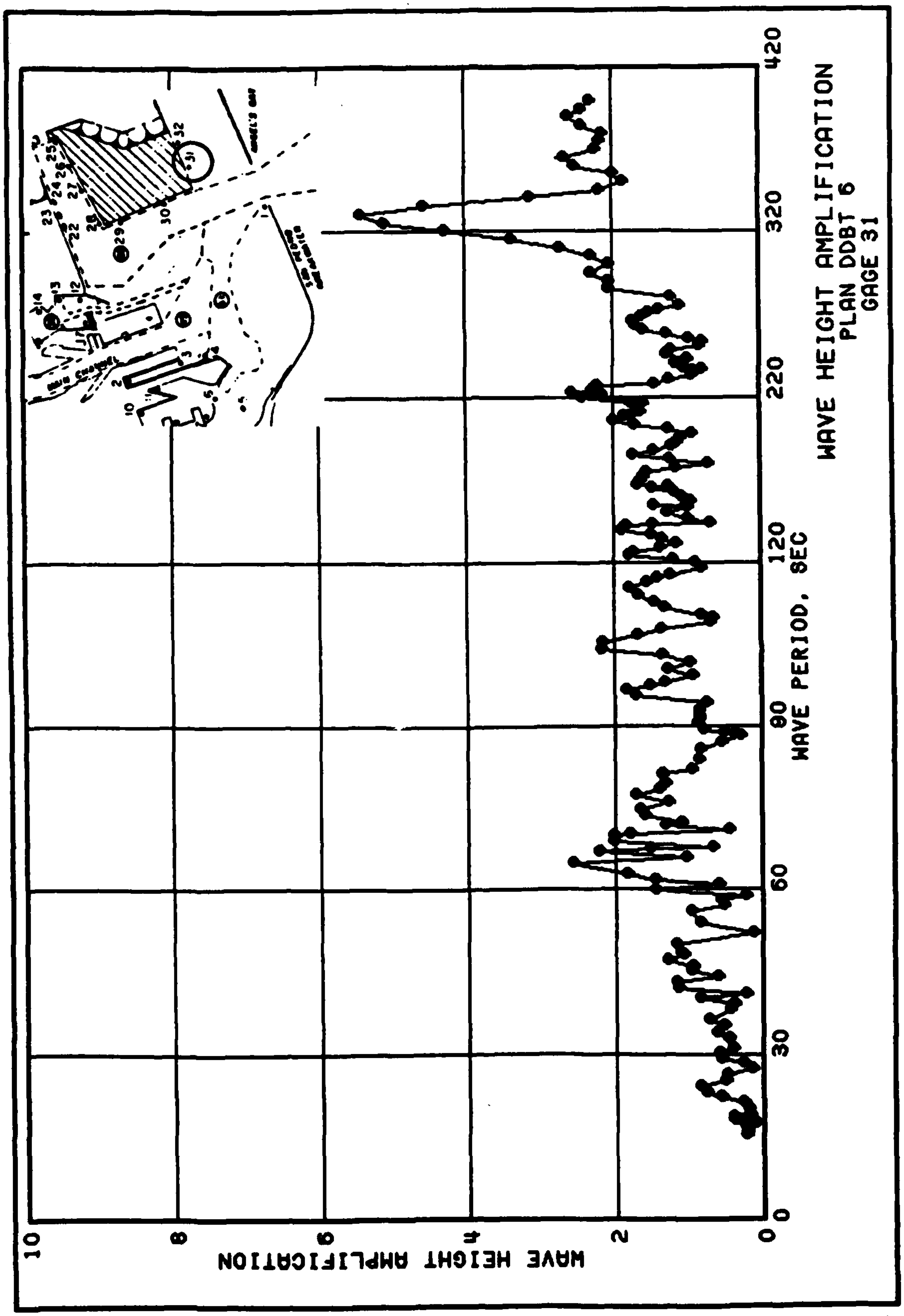

WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 30
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
0
30
60
90
120
220
320
420
1
2
3
4
5
MAIN CHANNEL

PLATE 150



WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 31
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
0
30
60
90
120
220
320
420
0
2
4
6
8
10

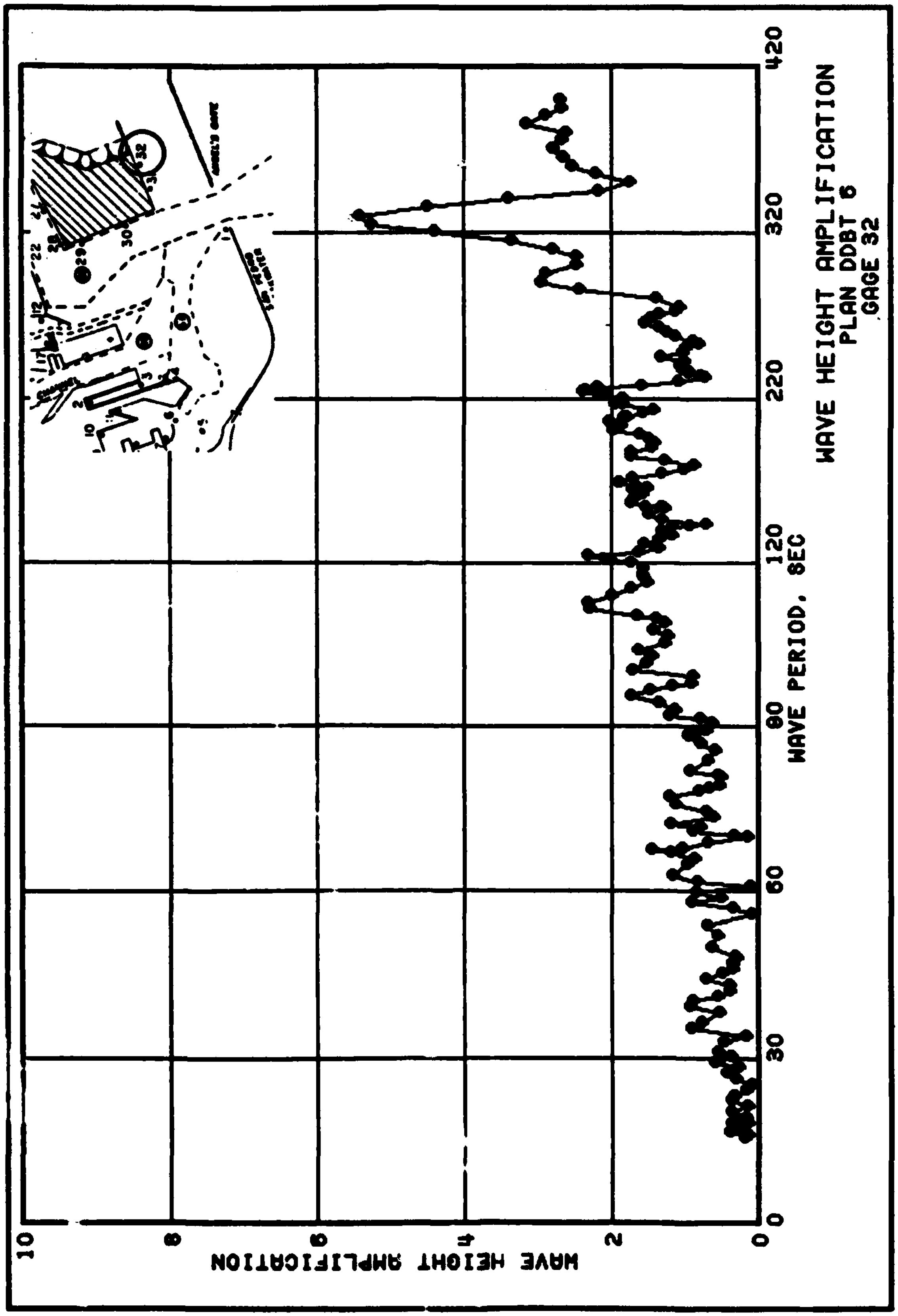

WAVE HEIGHT AMPLIFICATION
PLAN DDBT 6
GAGE 32
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
0
30
60
90
120
220
320
420
0
2
4
6
8
10

PLATE 152

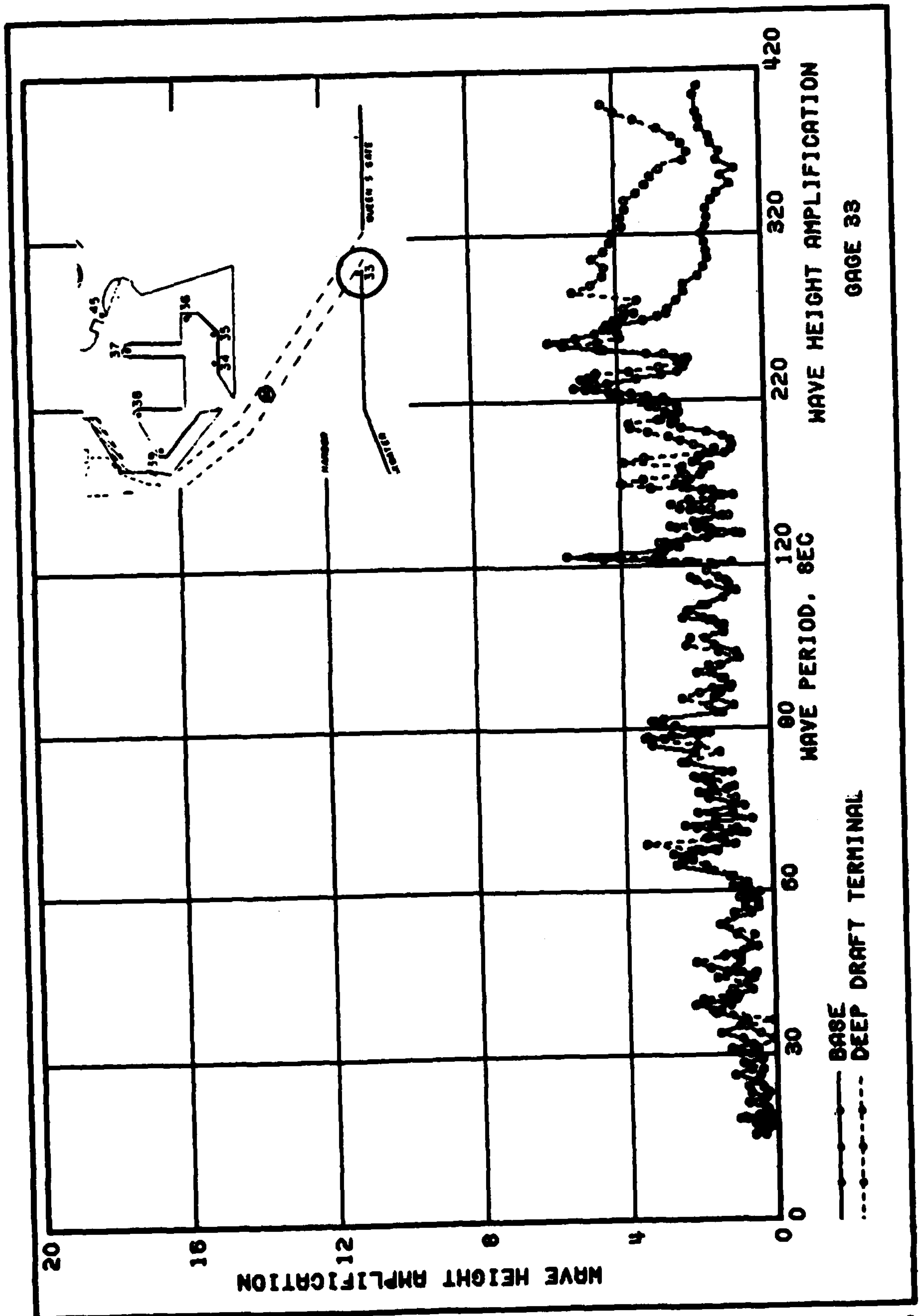

WAVE HEIGHT AMPLIFICATION
GAGE 33
WAVE HEIGHT AMPLIFICATION
WAVE PERIOD, SEC
BASE
DEEP DRAFT TERMINAL
0
30
60
90
120
220
320
420
0
4
8
12
16
20

PLATE 153

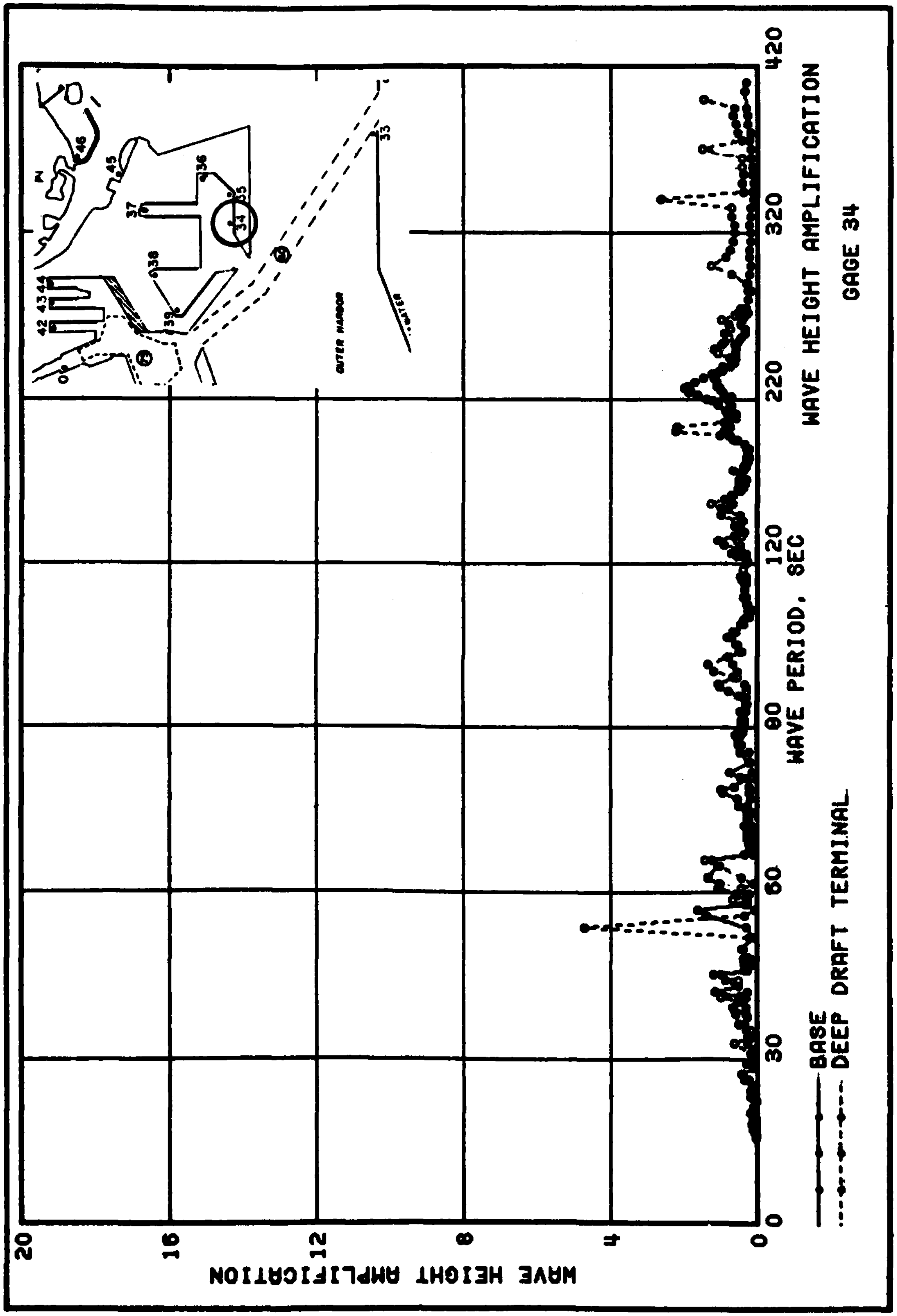
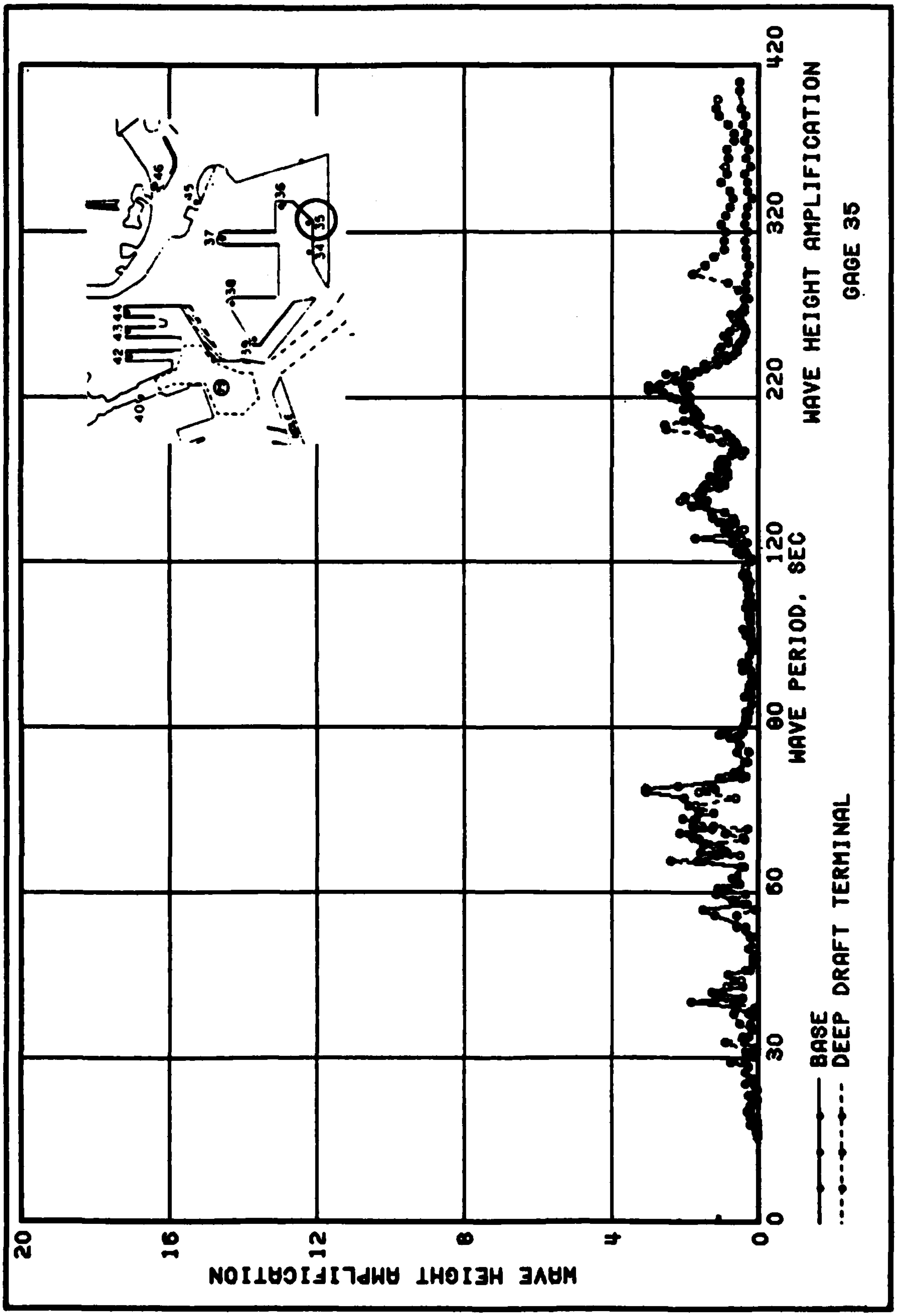
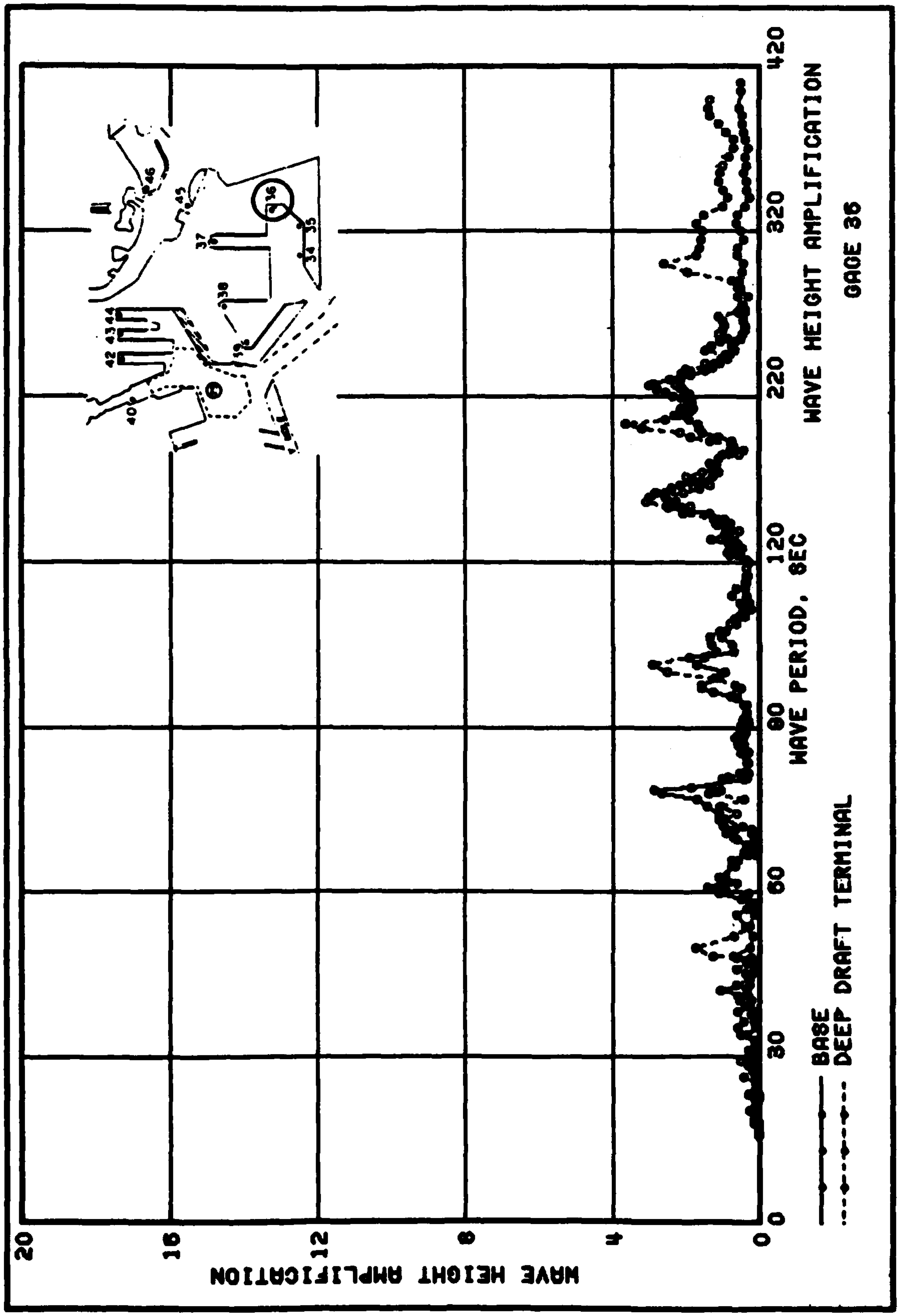

WAVE HEIGHT AMPLIFICATION
GAGE 34
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
BASE
DEEP DRAFT TERMINAL
OUTER HARBOR
0
30
60
90
120
220
320
420
0
4
8
12
16
20

PLATE 154


WAVE HEIGHT AMPLIFICATION
GAGE 35
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
BASE
DEEP DRAFT TERMINAL
0
30
60
90
120
220
320
420
0
4
8
12
16
20


WAVE HEIGHT AMPLIFICATION
GAGE 36
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
0
30
60
90
120
220
320
420
0
4
8
12
16
20
BASE
DEEP DRAFT TERMINAL

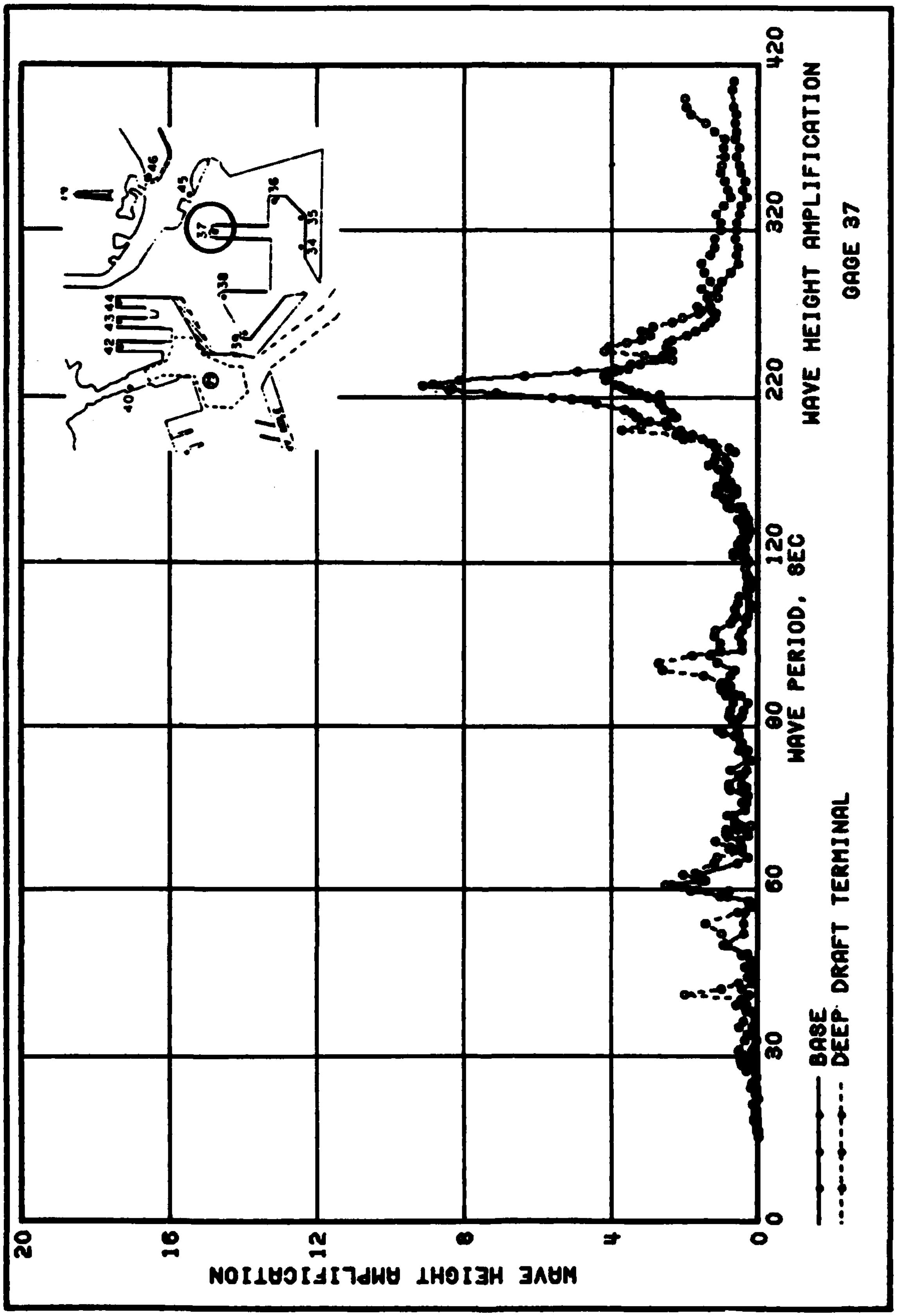

WAVE HEIGHT AMPLIFICATION
GAGE 37
WAVE HEIGHT AMPLIFICATION
0
4
8
12
16
20
WAVE PERIOD, SEC
0
30
60
90
120
220
320
420
BASE
DEEP DRAFT TERMINAL

PLATE 157

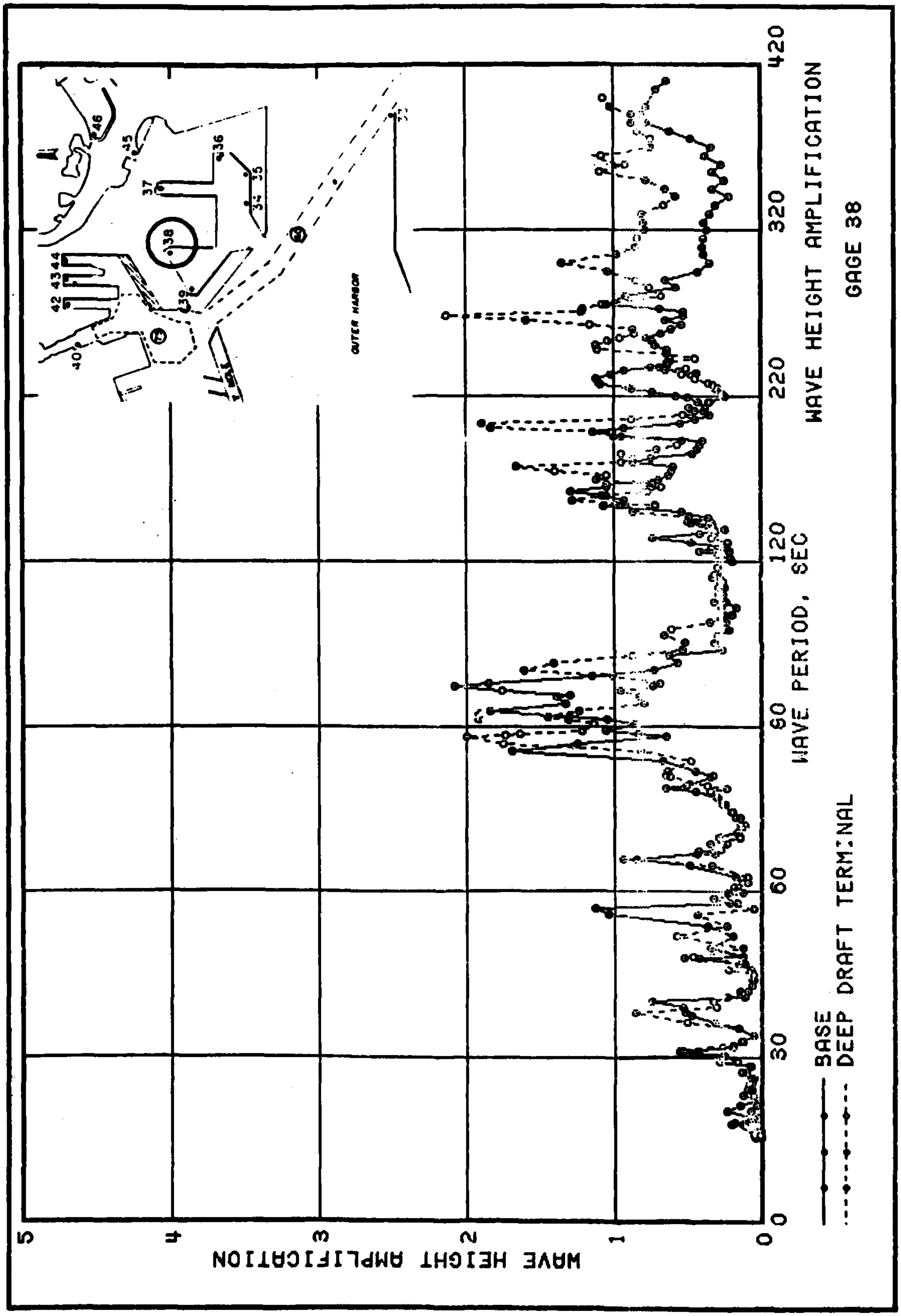
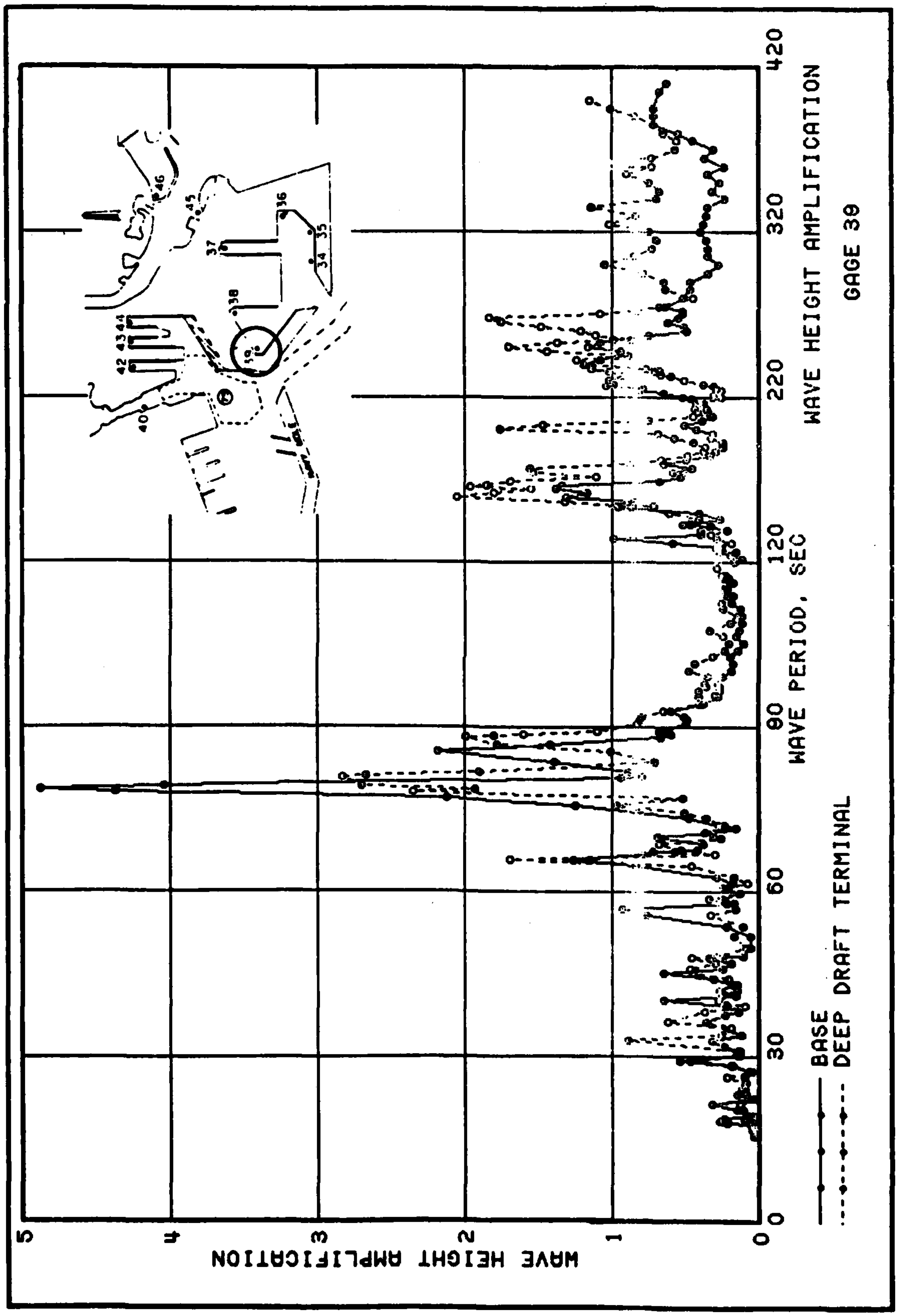

WAVE HEIGHT AMPLIFICATION
GAGE 38
WAVE HEIGHT AMPLIFICATION
WAVE PERIOD, SEC
0
1
2
3
4
5
0
30
60
90
120
220
320
420
BASE
DEEP DRAFT TERMINAL
OUTER HARBOR
34
35
36
37
38
39
40
42
43
44
45
46

PLATE 158


WAVE HEIGHT AMPLIFICATION
GAGE 39
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
BASE
DEEP DRAFT TERMINAL
0
30
60
90
120
220
320
420
0
1
2
3
4
5

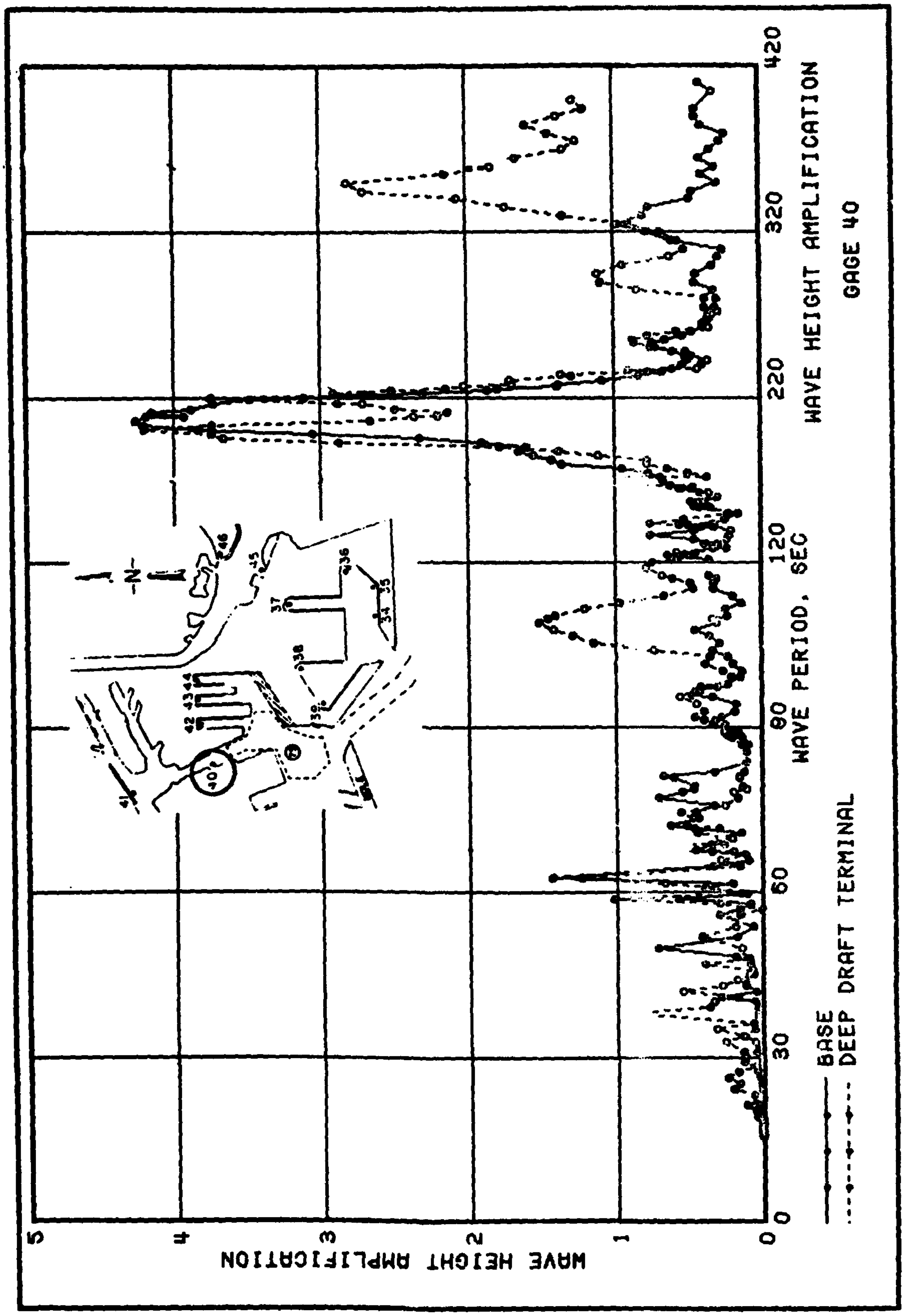
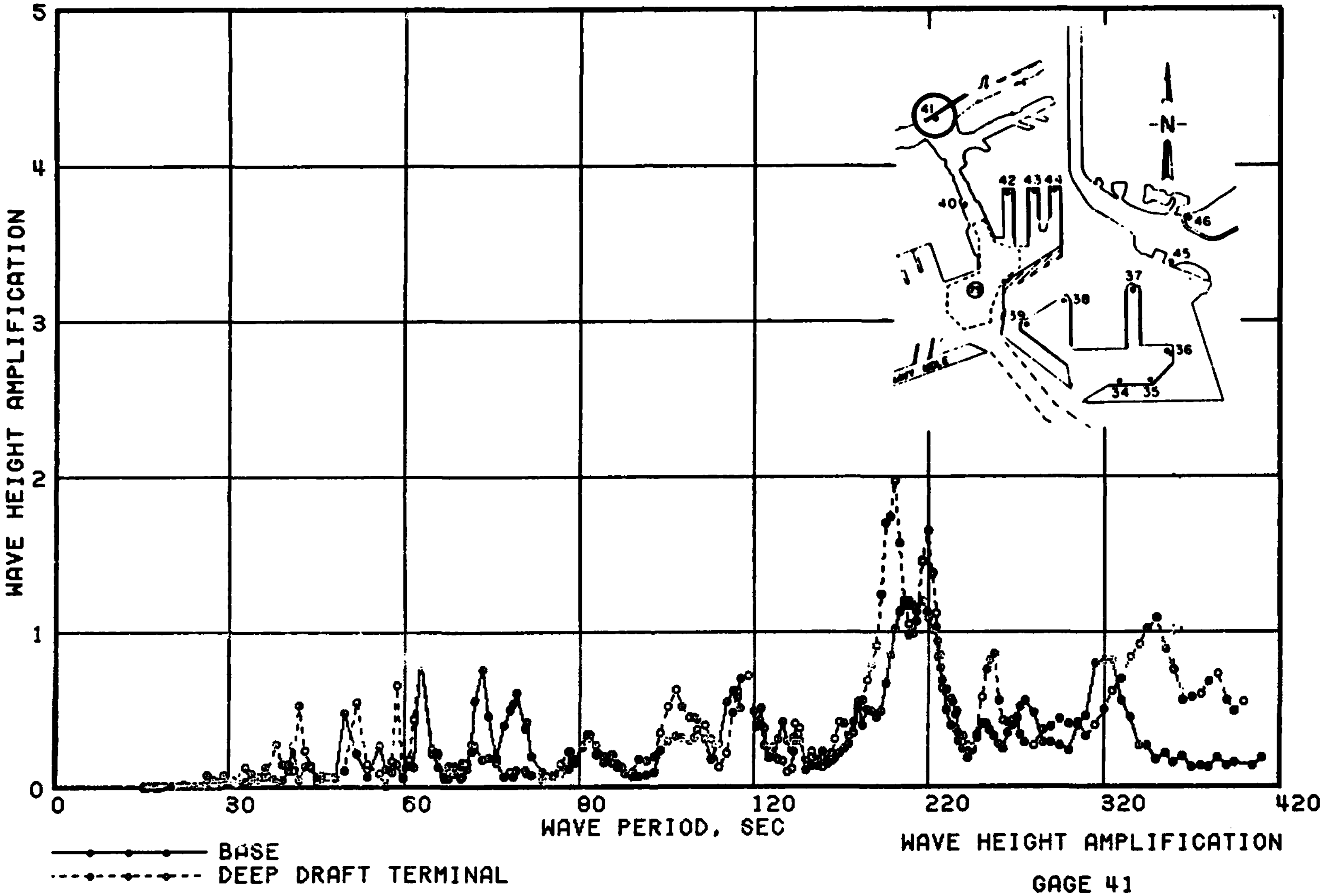

WAVE HEIGHT AMPLIFICATION
GAGE 40
WAVE HEIGHT AMPLIFICATION
WAVE PERIOD, SEC
BASE
DEEP DRAFT TERMINAL
0
1
2
3
4
5
0
30
60
90
120
220
320
420
-N-

PLATE 160



WAVE HEIGHT AMPLIFICATION

GAGE 41

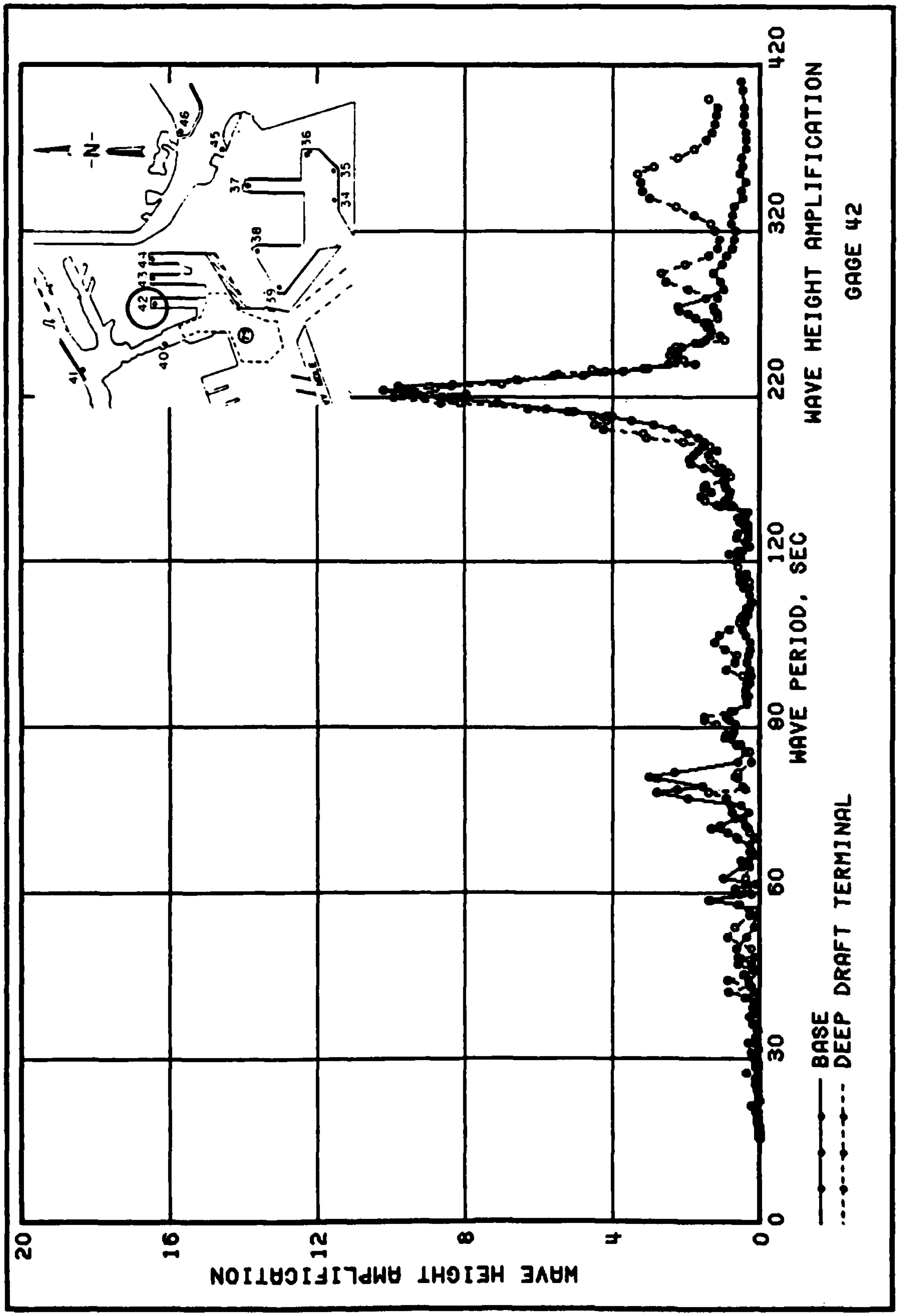

WAVE HEIGHT AMPLIFICATION
GAGE 42
WAVE HEIGHT AMPLIFICATION
WAVE PERIOD, SEC
0
30
60
90
120
220
320
420
0
4
8
12
16
20
BASE
DEEP DRAFT TERMINAL
-N-
34
35
36
37
38
39
40
41
42
43
44
45
46

PLATE 162

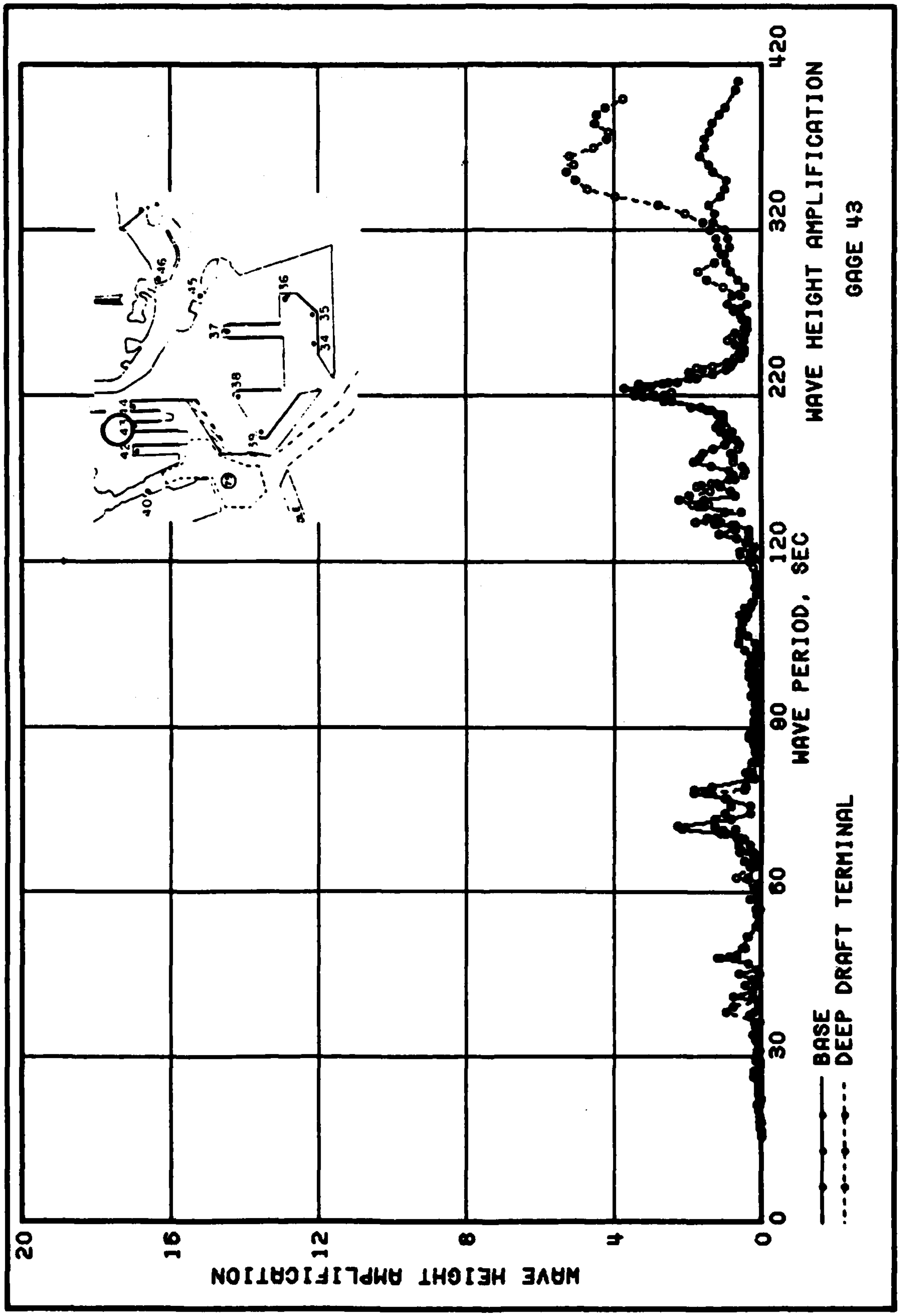
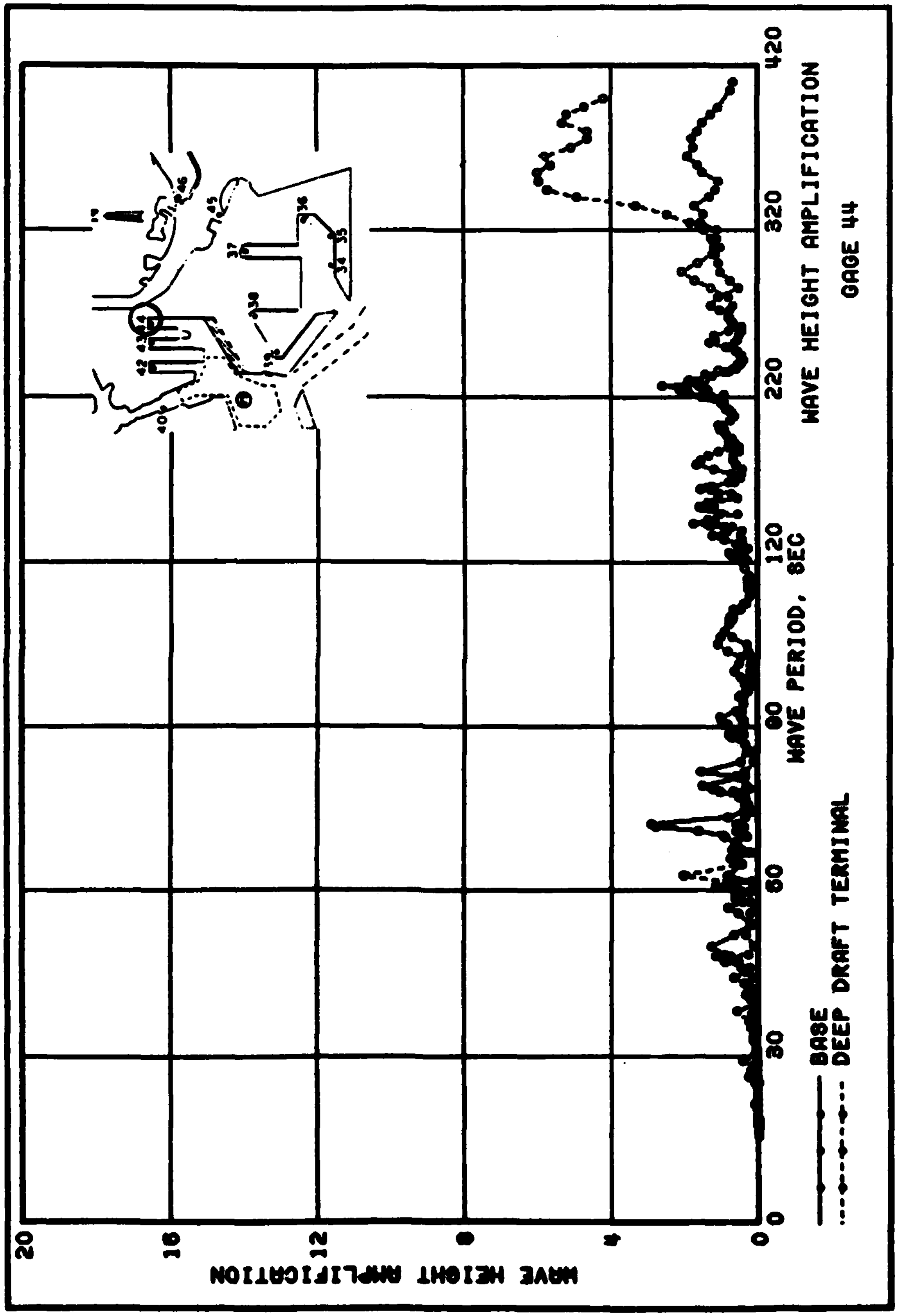
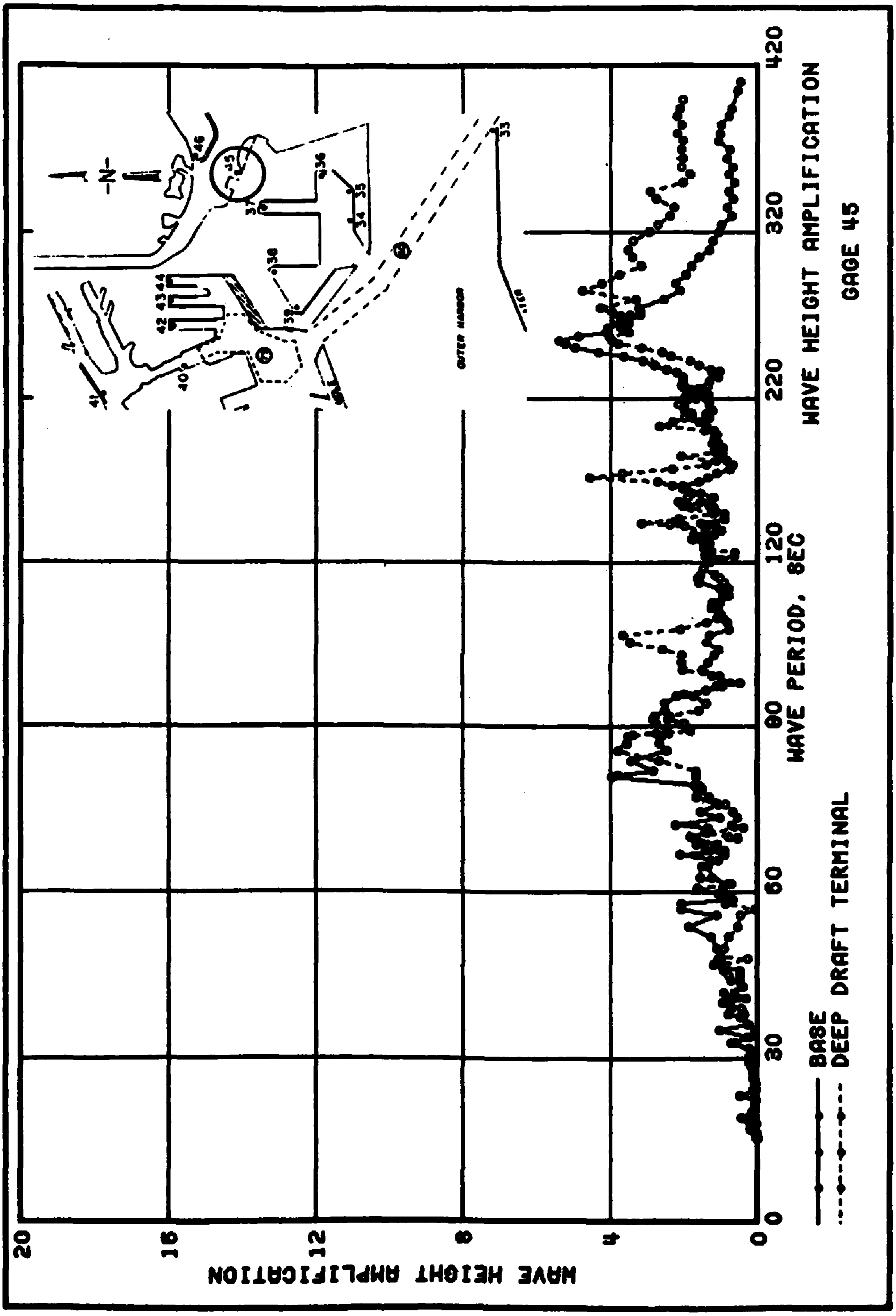

WAVE HEIGHT AMPLIFICATION
GAGE 43
WAVE HEIGHT AMPLIFICATION
WAVE PERIOD, SEC
BASE
DEEP DRAFT TERMINAL
0
30
60
90
120
220
320
420
0
4
8
12
16
20

PLATE 163



WAVE HEIGHT AMPLIFICATION
GAGE 44
WAVE PERIOD, SEC
WAVE HEIGHT AMPLIFICATION
BASE
DEEP DRAFT TERMINAL
0
30
60
90
120
220
320
420
4
8
12
16
20

PLATE 164


WAVE HEIGHT AMPLIFICATION
GAGE 45
WAVE HEIGHT AMPLIFICATION
WAVE PERIOD, SEC
0
30
60
90
120
220
320
420
0
4
8
12
16
20
BASE
DEEP DRAFT TERMINAL
OUTER HARBOR
N

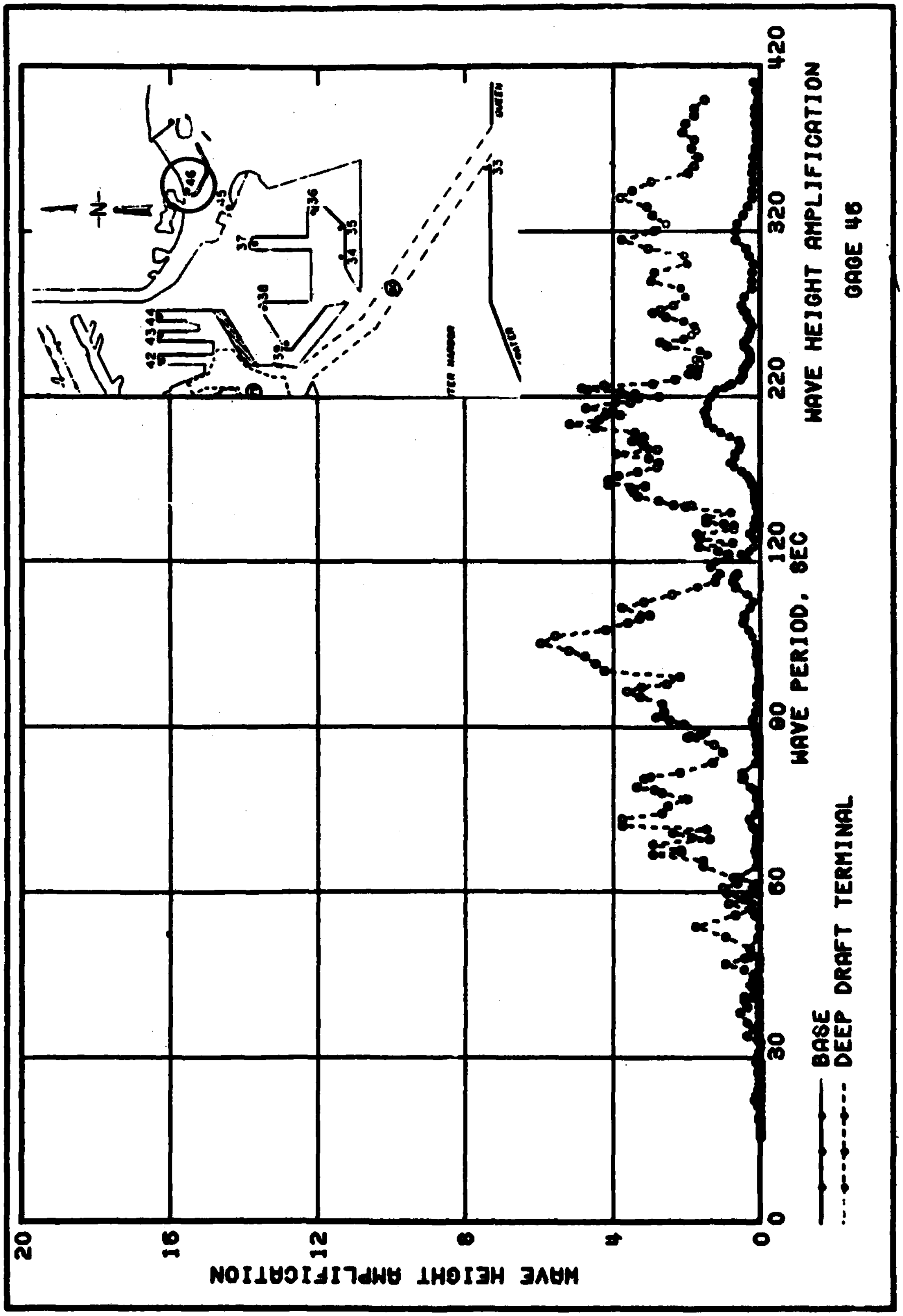
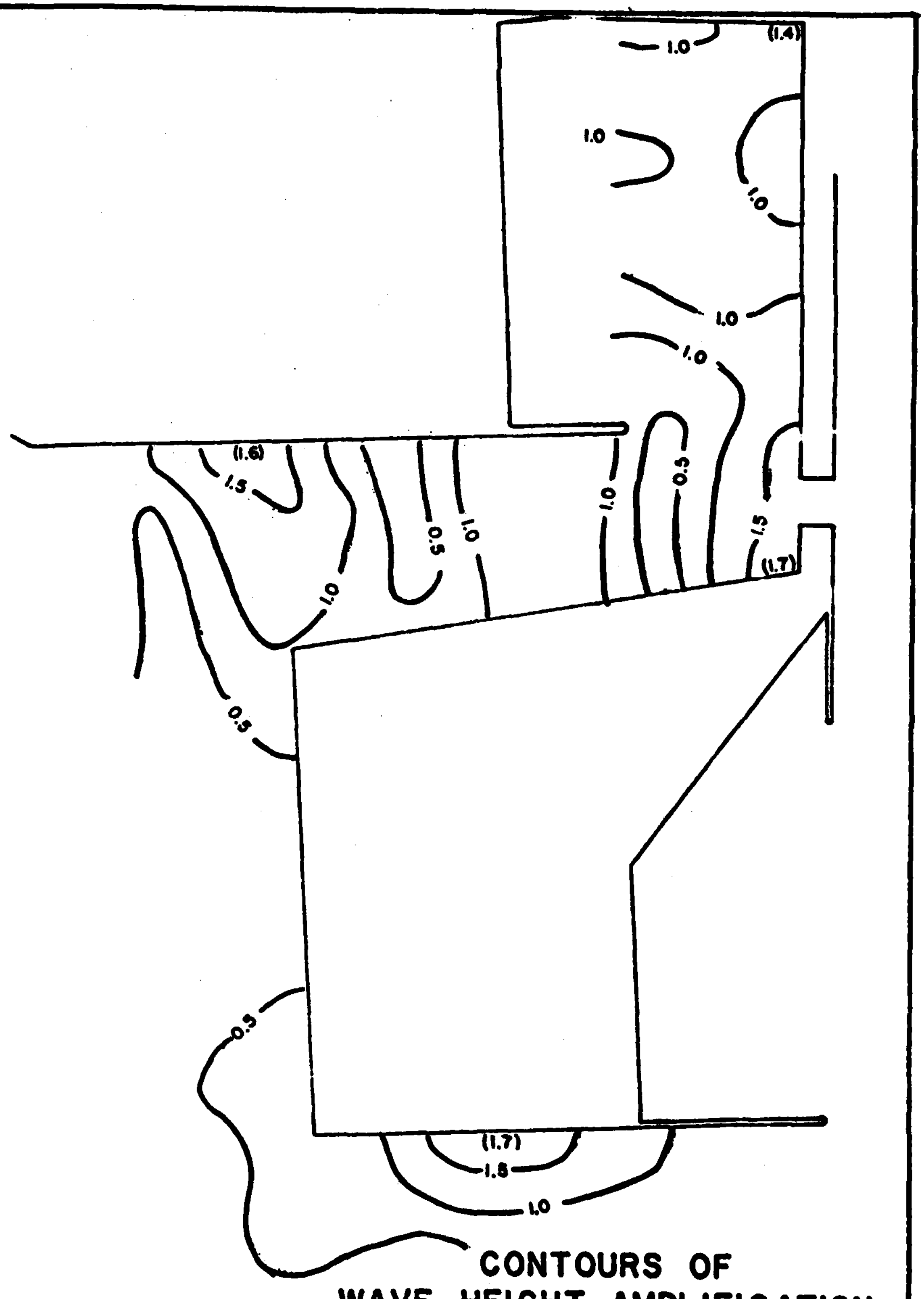

WAVE HEIGHT AMPLIFICATION
GAGE 46
WAVE PERIOD, SEC
0
30
60
90
120
220
320
420
WAVE HEIGHT AMPLIFICATION
0
4
8
12
16
20
BASE
DEEP DRAFT TERMINAL

PLATE 166



CONTOURS OF WAVE HEIGHT AMPLIFICATION

DEEP DRAFT COAL TERMINAL
100 SEC

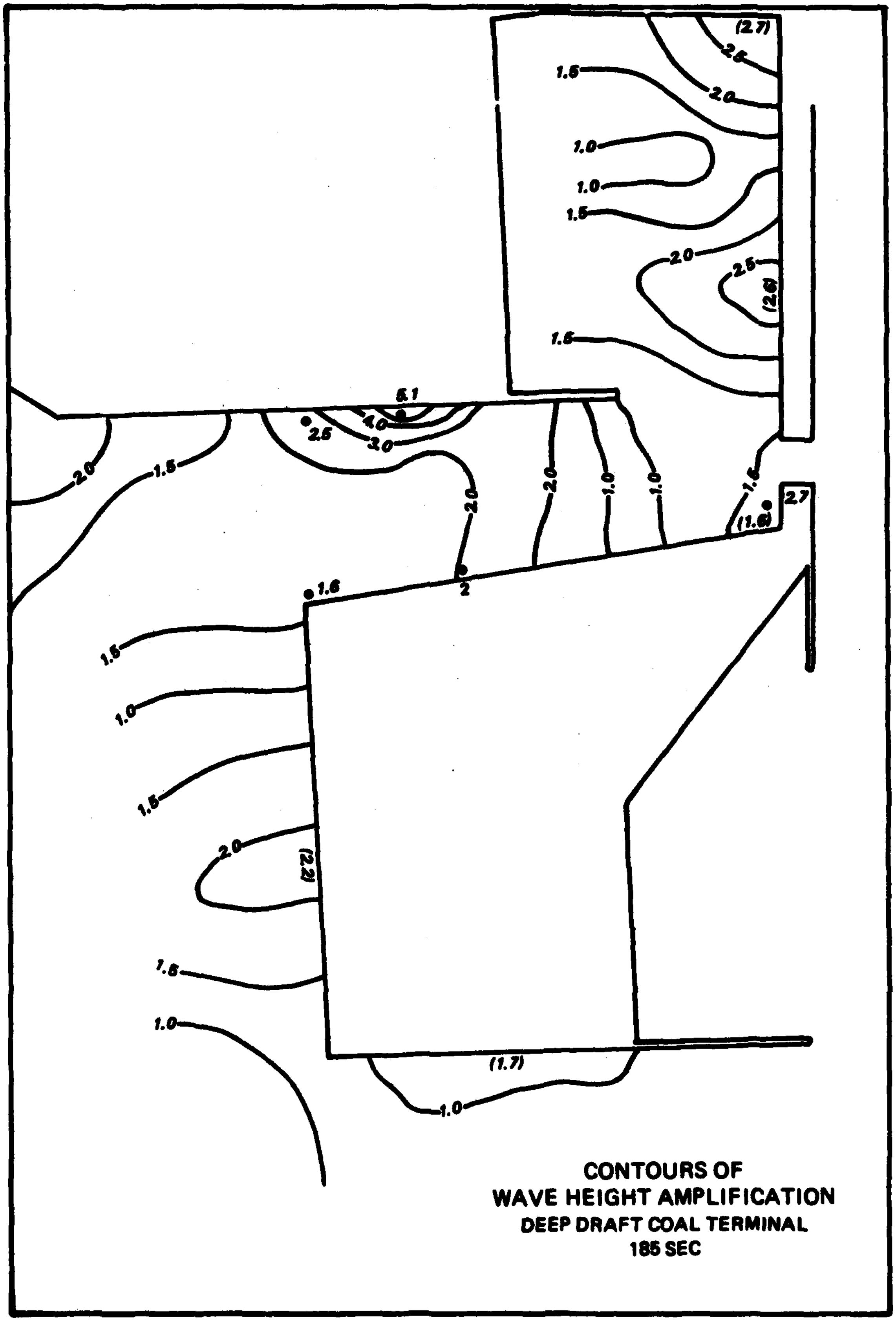
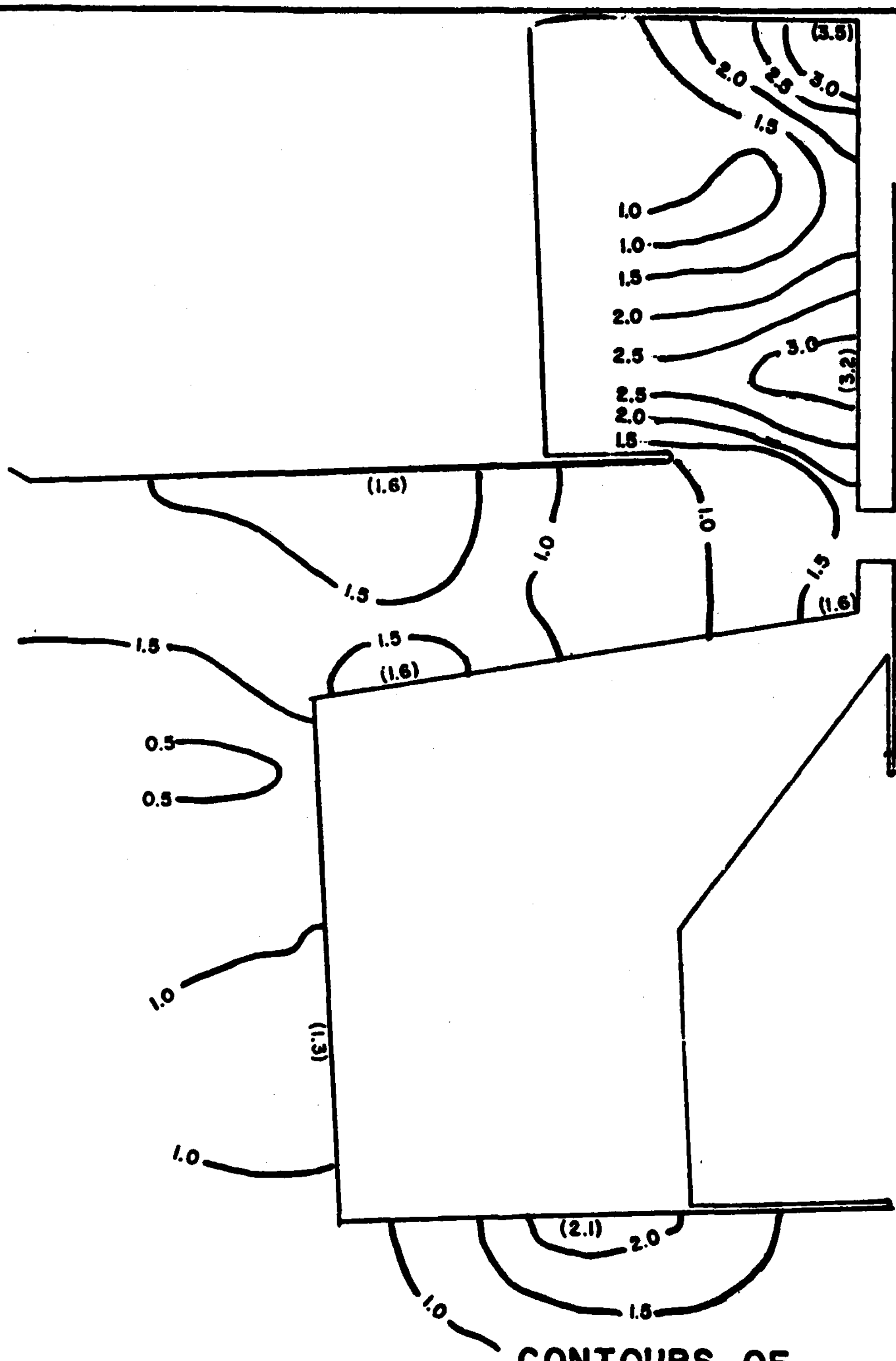

(2.7)
2.5
1.5
2.0
1.0
1.0
1.5
2.0
2.5
(2.6)
1.5
5.1
2.5
4.0
3.0
2.0
1.5
2.0
2.0
1.0
1.0
1.5
2.7
(1.6)
1.6
2
1.5
1.0
1.5
2.0
(2.2)
1.5
1.0
(1.7)
1.0
CONTOURS OF
WAVE HEIGHT AMPLIFICATION
DEEP DRAFT COAL TERMINAL
185 SEC

PLATE 168



CONTOURS OF
WAVE HEIGHT AMPLIFICATION

DEEP DRAFT COAL TERMINAL
200 SEC

PLATE 169

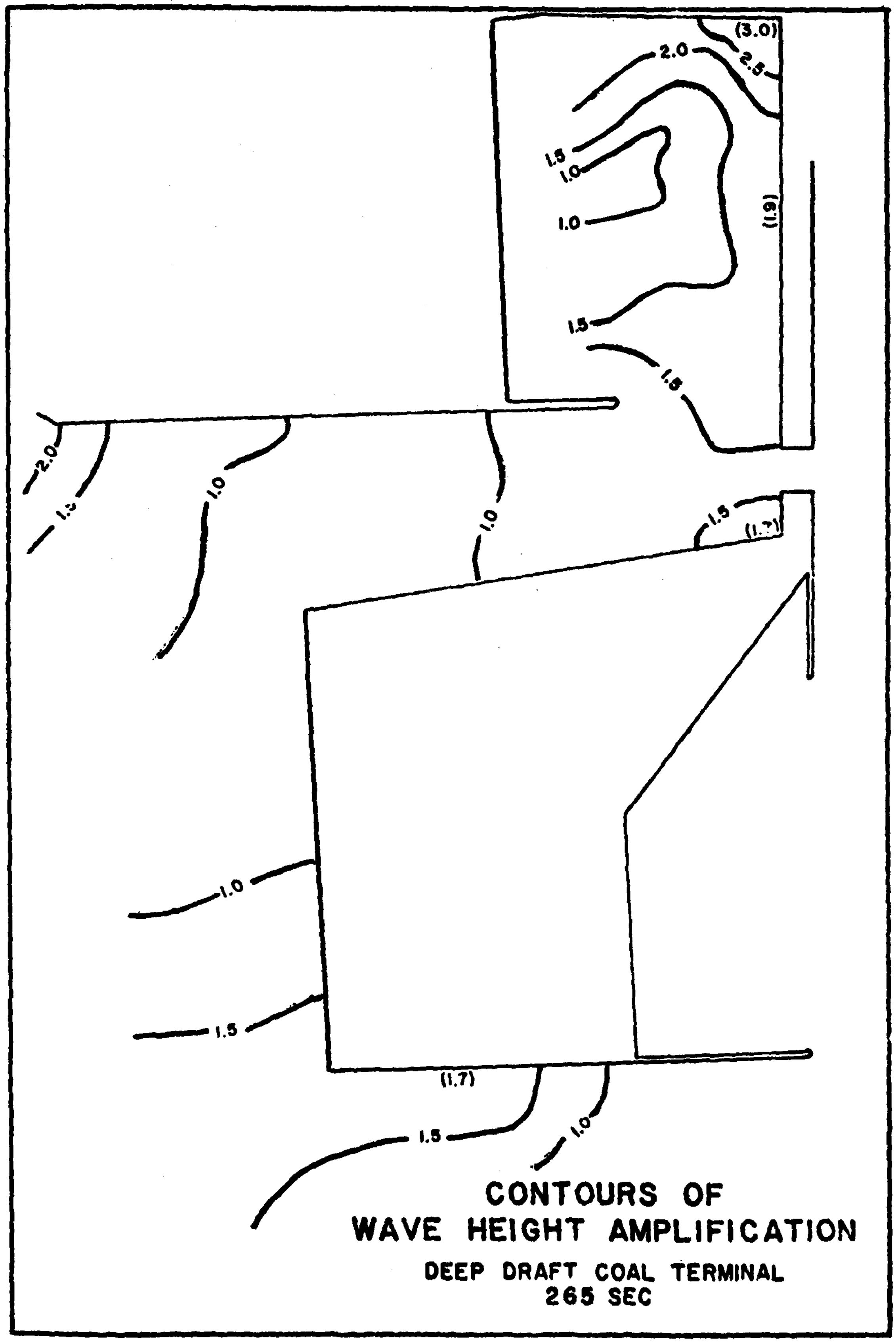

(3.0)
2.0
2.5
1.5
1.0
1.0
(1.9)
1.5
1.5
2.0
1.5
1.0
1.0
1.5
(1.7)
1.0
1.5
(1.7)
1.5
1.0
CONTOURS OF
WAVE HEIGHT AMPLIFICATION
DEEP DRAFT COAL TERMINAL
265 SEC

PLATE 170

END

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